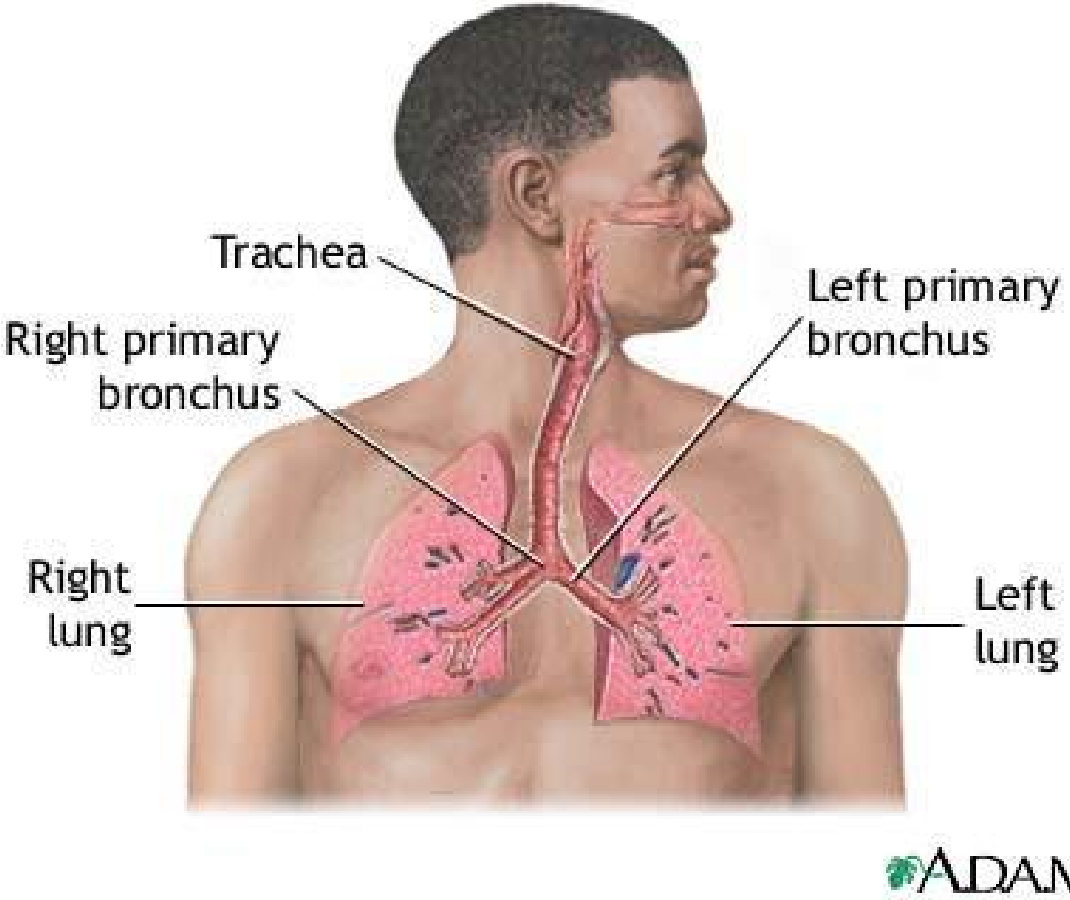
Respiratory System

Functions

- Gas exchange
- Smell
- Filters inspired air
- Sound production



Respiration

The exchange of gases between the atmosphere, blood and cells.

- Involves three processes
  - **Pulmonary ventilation**- inspiration and expiration.
  - **External repiration**- the exchange of gas between the lungs and blood.
  - **Internal respiration**- the exchange of gases between the blood and cells.

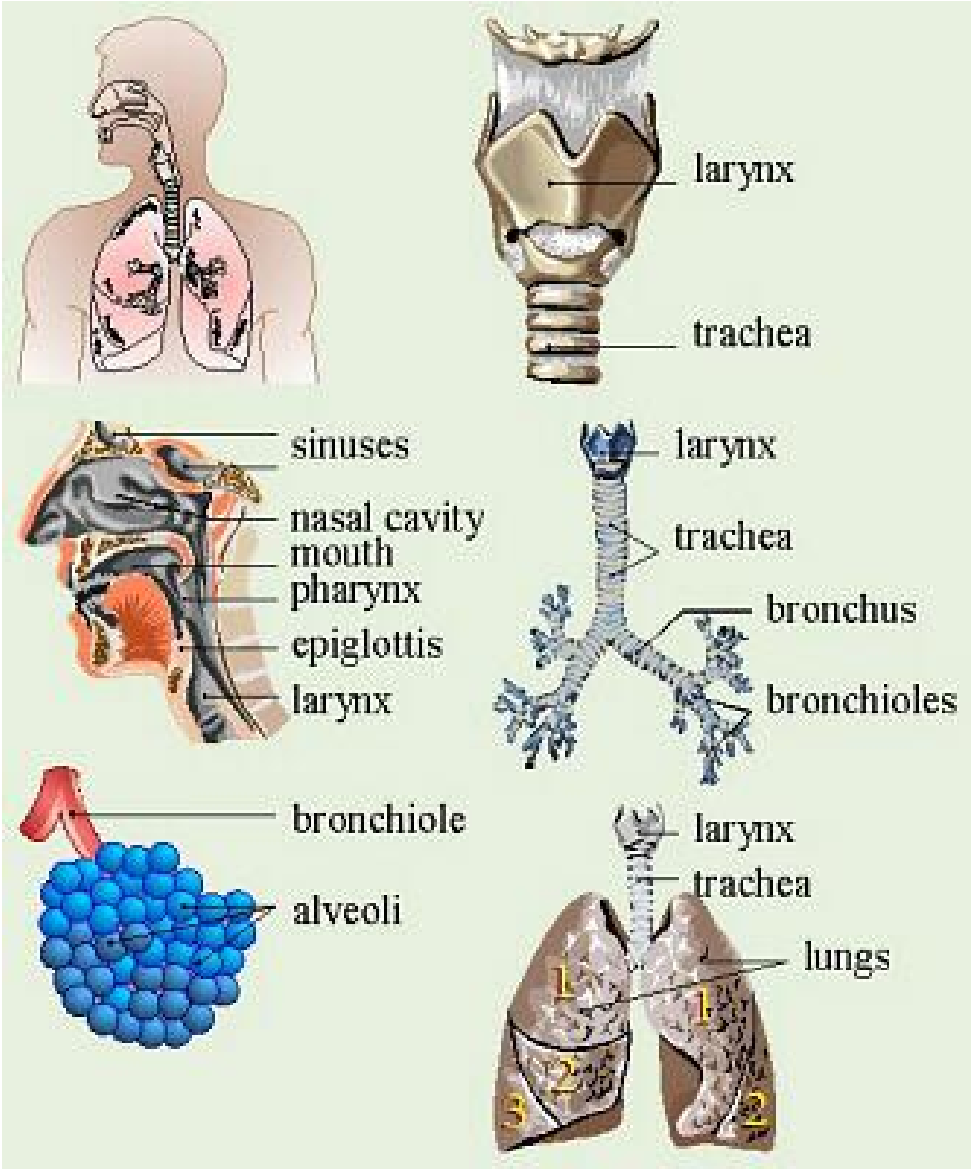
Structures of the Respiratory System

Upper Respiratory System

- Nose
- Pharynx (throat)

Lower Respiratory System

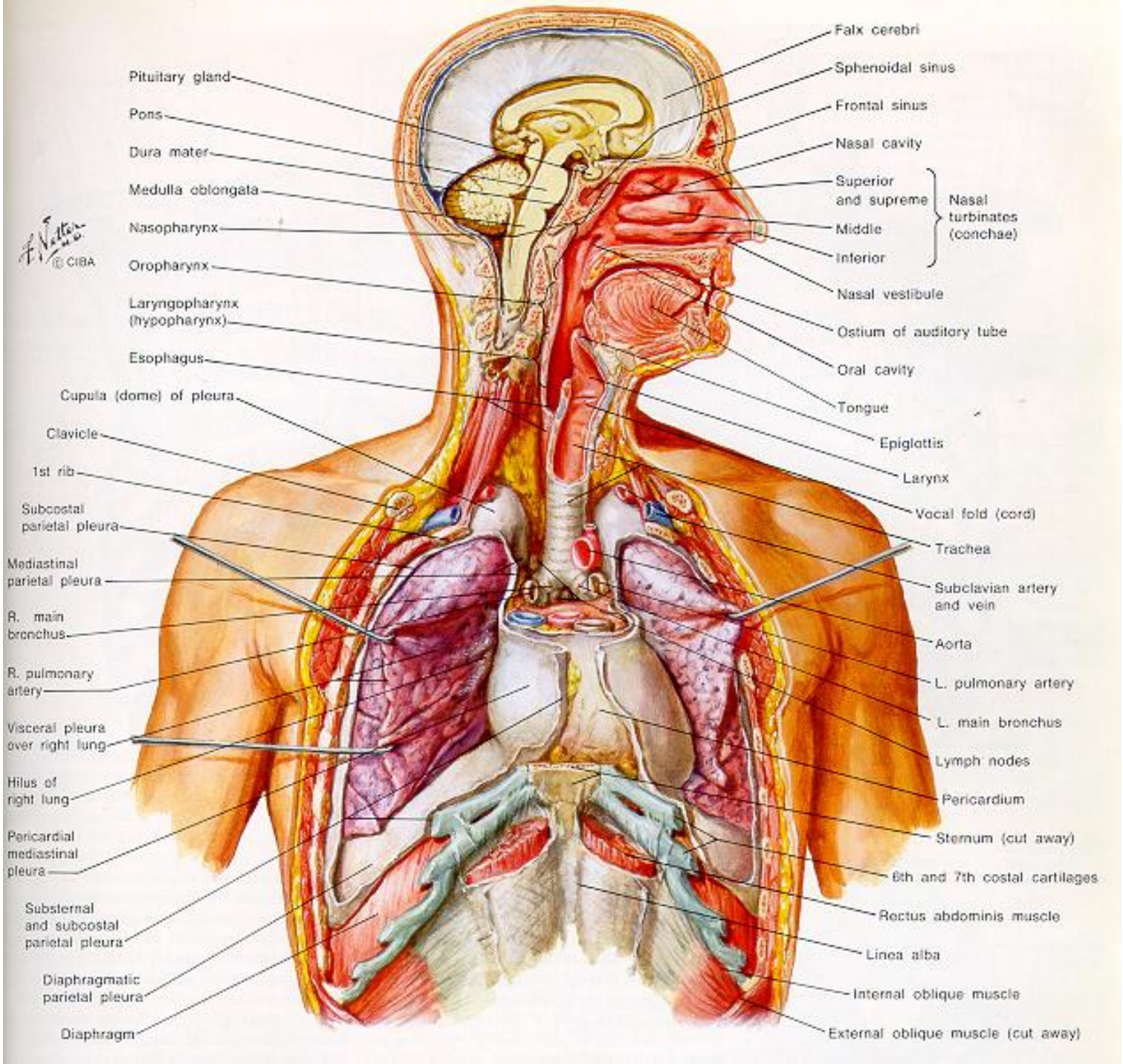
- larynx (voice box)
- Trachea (windpipe)
- Bronchi
- Lungs



Structures of the Respiratory System

Functionally, the respiratory system consist of two parts

- Conducting portion- a series of interconnected tubes and cavities that conduct air to the lung.
- Respiratory portion- where gas exchange occurs.


Falx cerebri
Sphenoidal sinus
Frontal sinus
Nasal cavity
Superior and supreme
Middle
Inferior
Nasal turbinates (conchae)
Nasal vestibule
Ostium of auditory tube
Oral cavity
Tongue
Epiglottis
Larynx
Vocal fold (cord)
Trachea
Subclavian artery and vein
Aorta
L. pulmonary artery
L. main bronchus
Lymph nodes
Pericardium
Sternum (cut away)
6th and 7th costal cartilages
Rectus abdominis muscle
Linea alba
Internal oblique muscle
External oblique muscle (cut away)
Pituitary gland
Pons
Dura mater
Medulla oblongata
Nasopharynx
Oropharynx
Laryngopharynx (hypopharynx)
Esophagus
Cupula (dome) of pleura
Clavicle
1st rib
Subcostal parietal pleura
Mediastinal parietal pleura
R. main bronchus
R. pulmonary artery
Visceral pleura over right lung
Hilus of right lung
Pericardial mediastinal pleura
Substernal and subcostal parietal pleura
Diaphragmatic parietal pleura
Diaphragm
F. Netter M.D.
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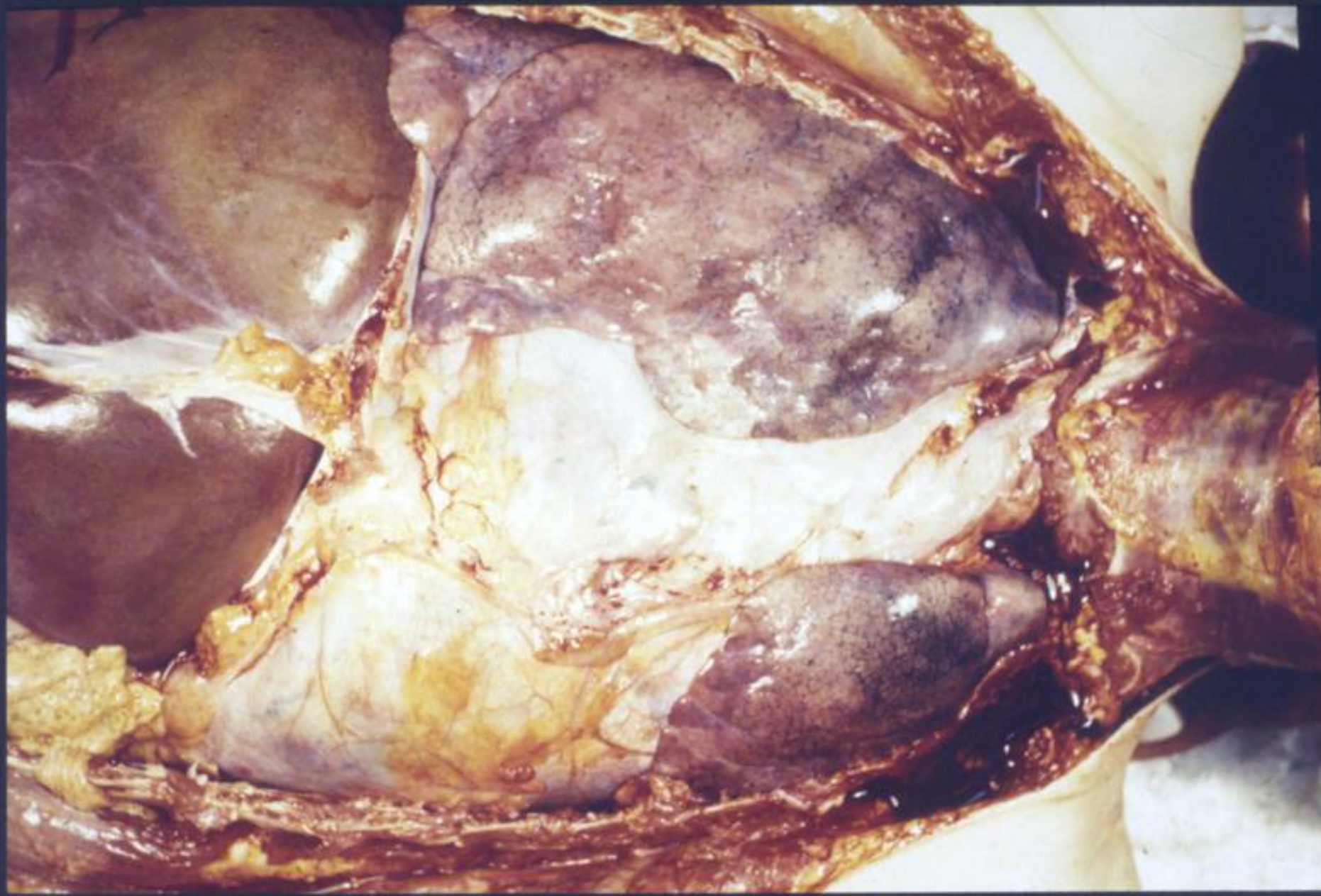
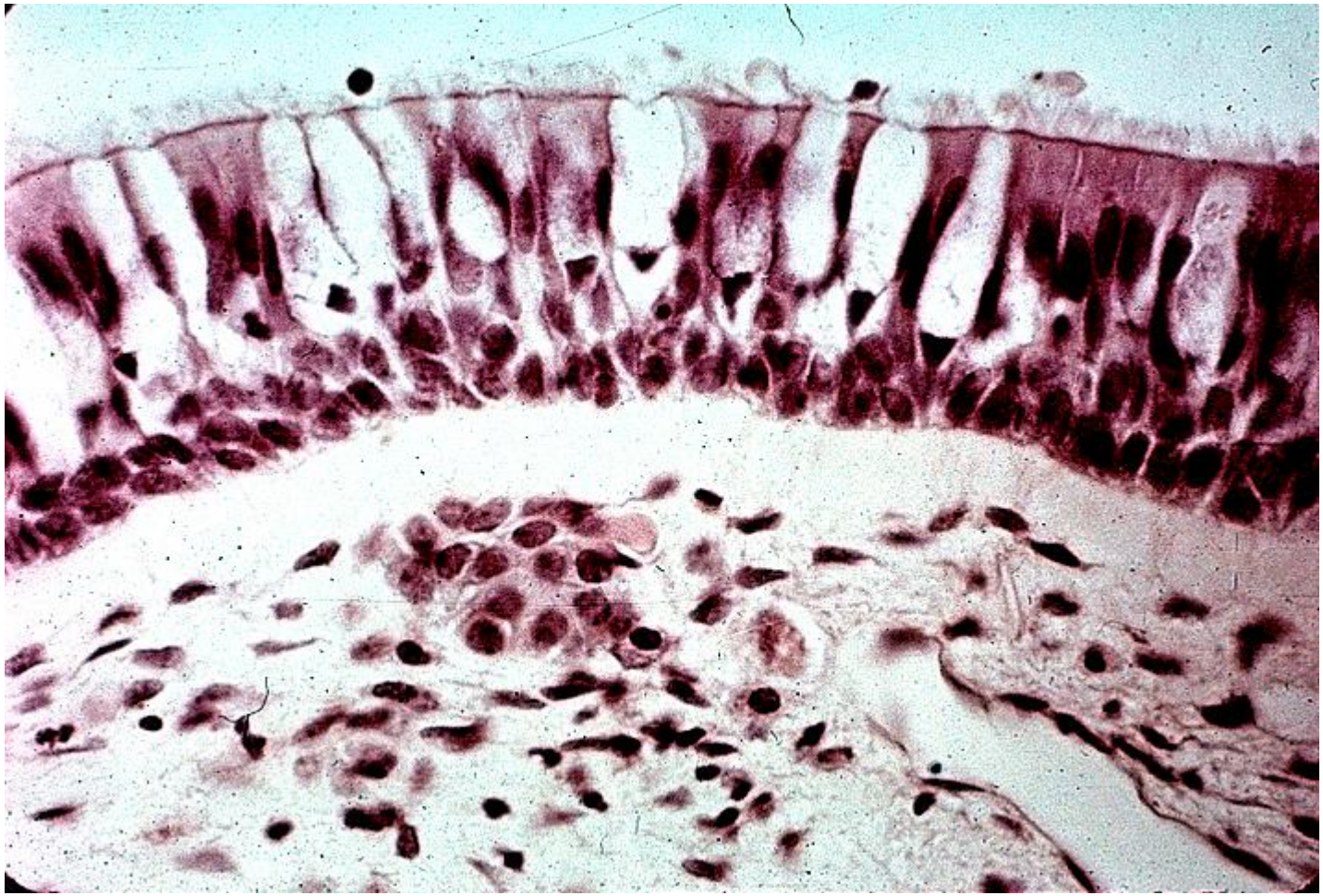


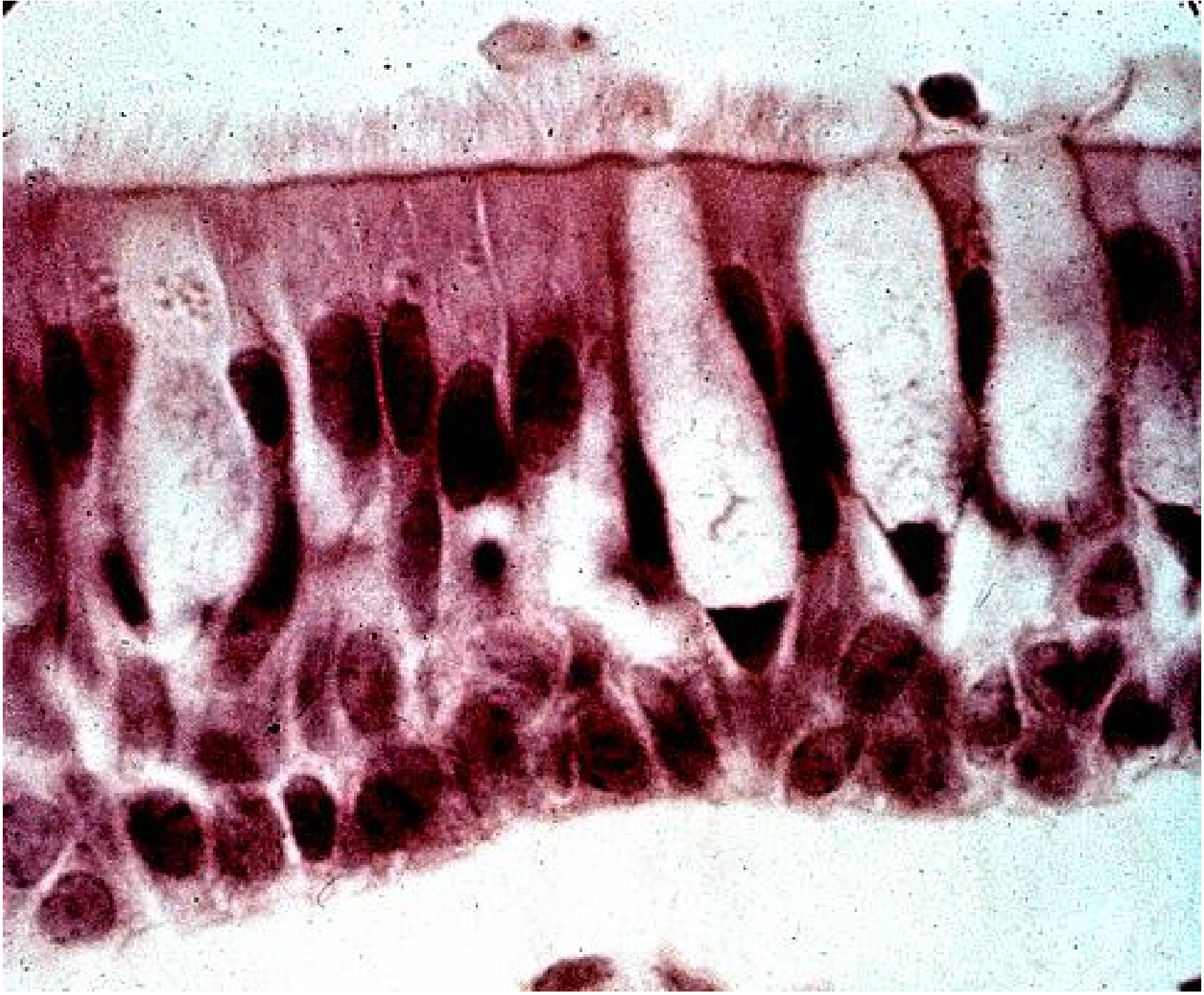
Nose

Function

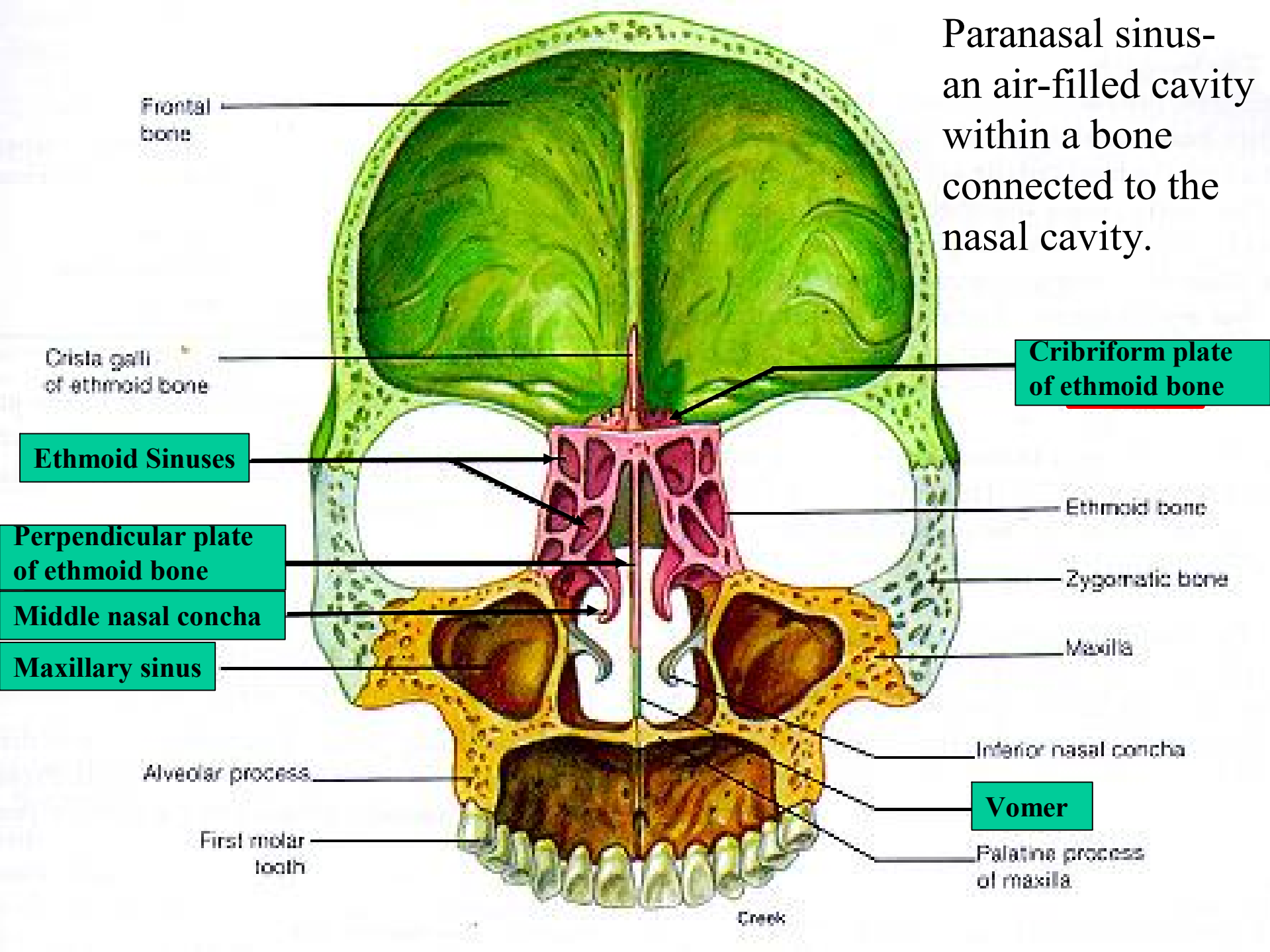
- Warms, moistens, and filters incoming air
  - nasal hairs
  - superior, middle, and inferior nasal conchae (turbinates)- lined with mucus membranes containing goblet cells and is vascular (moistens and traps particles).
- Receives olfactory stimulation
  - above the superior nasal conchae is the olfactory epithelium (olfactory bulb), which receives olfactory stimuli.
- Provides a resonating chamber for speech sounds
  - ethmoid, maxillary, sphenoid, and frontal sinuses
- Connects the eyes with the nose via the nasolacrimal duct.

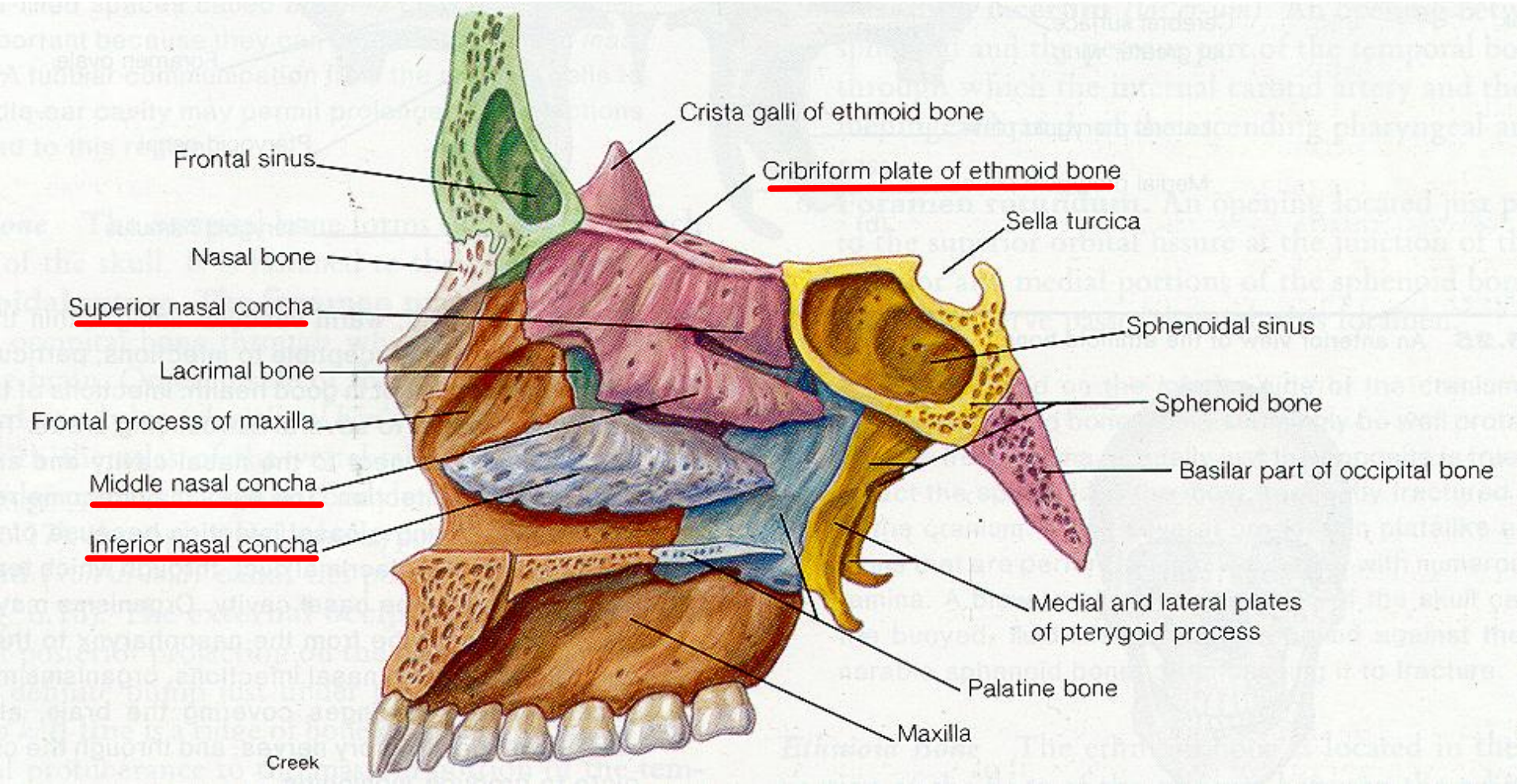
Nasal Respiratory Epithelium



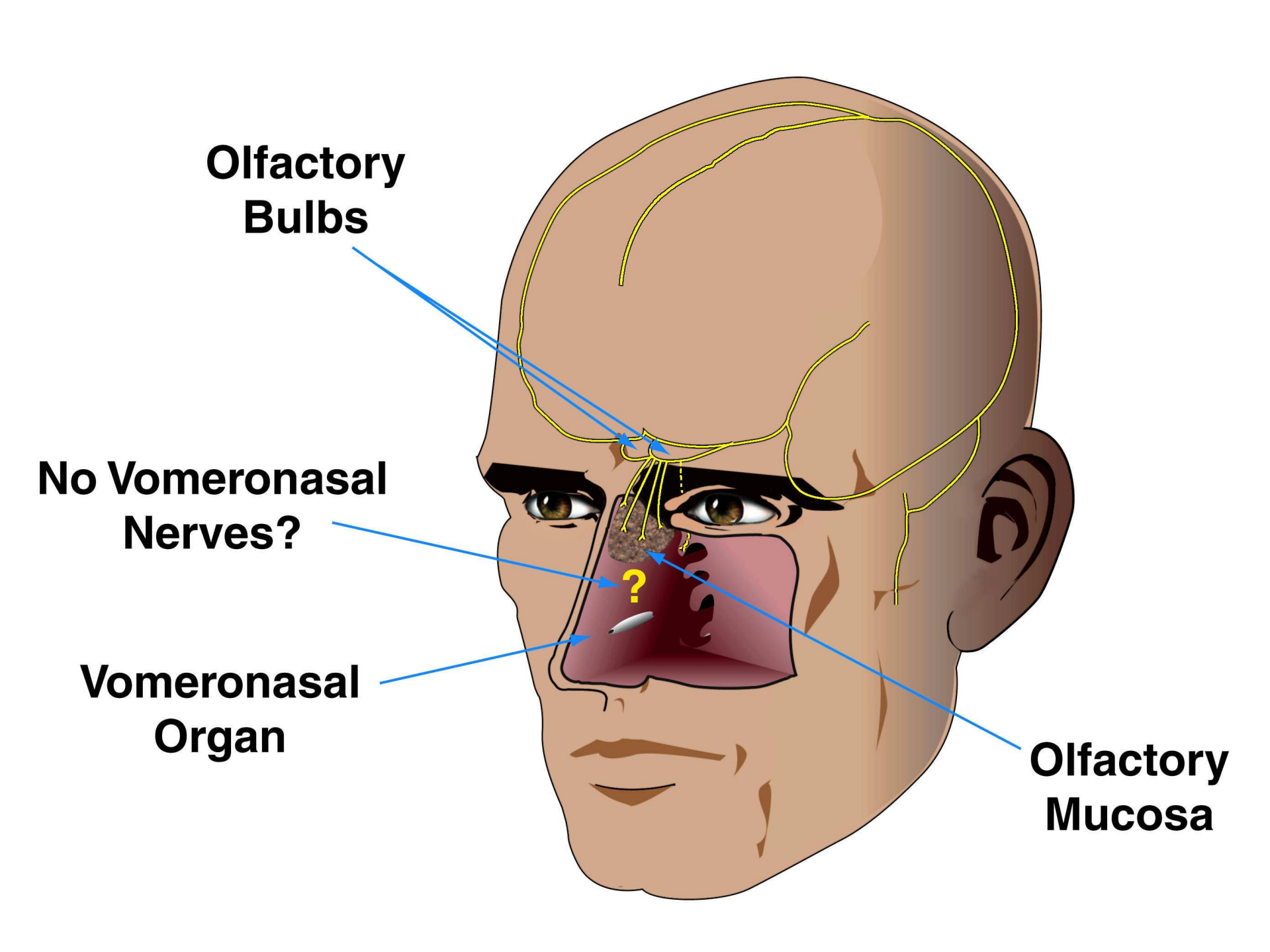


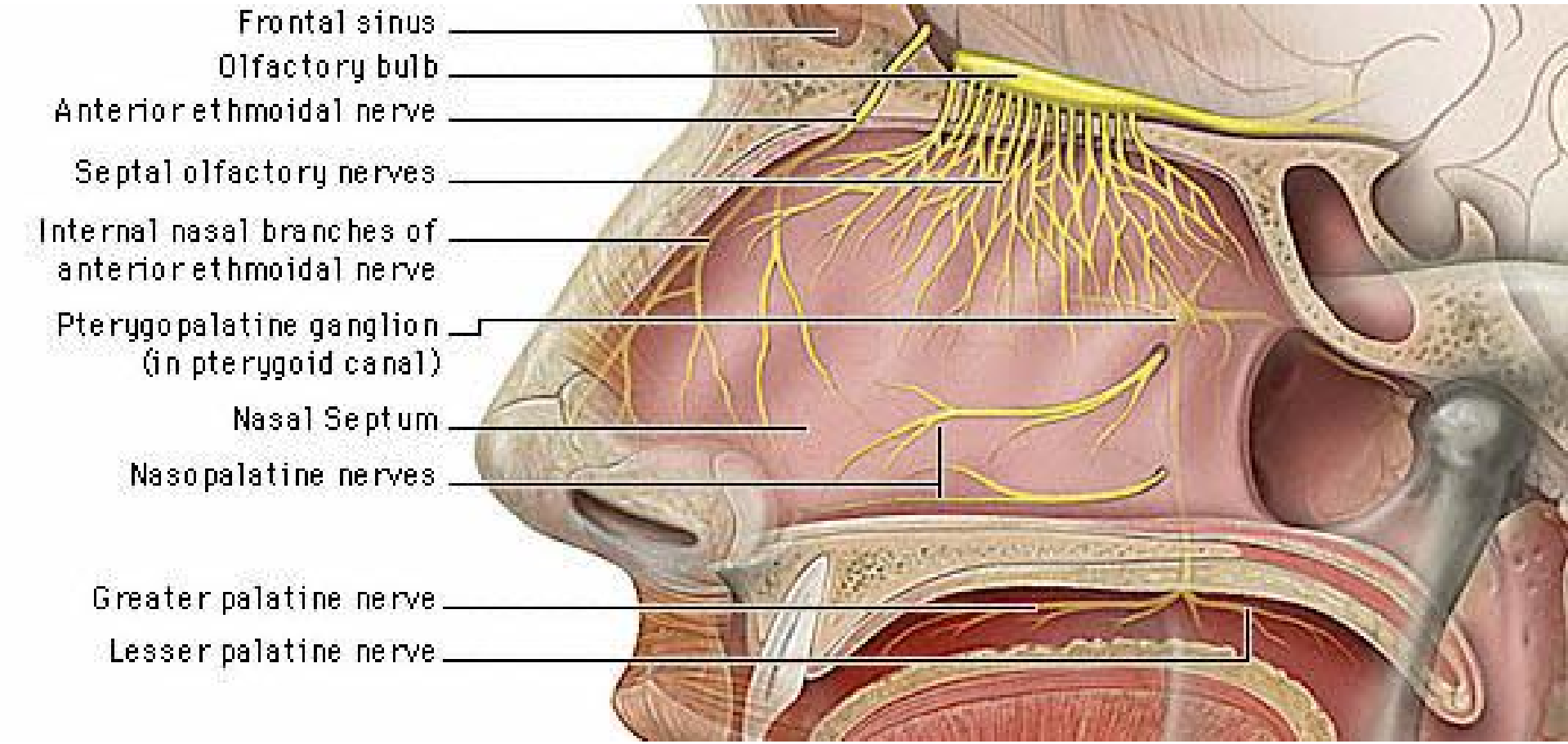
Paranasal sinus- an air-filled cavity within a bone connected to the nasal cavity.

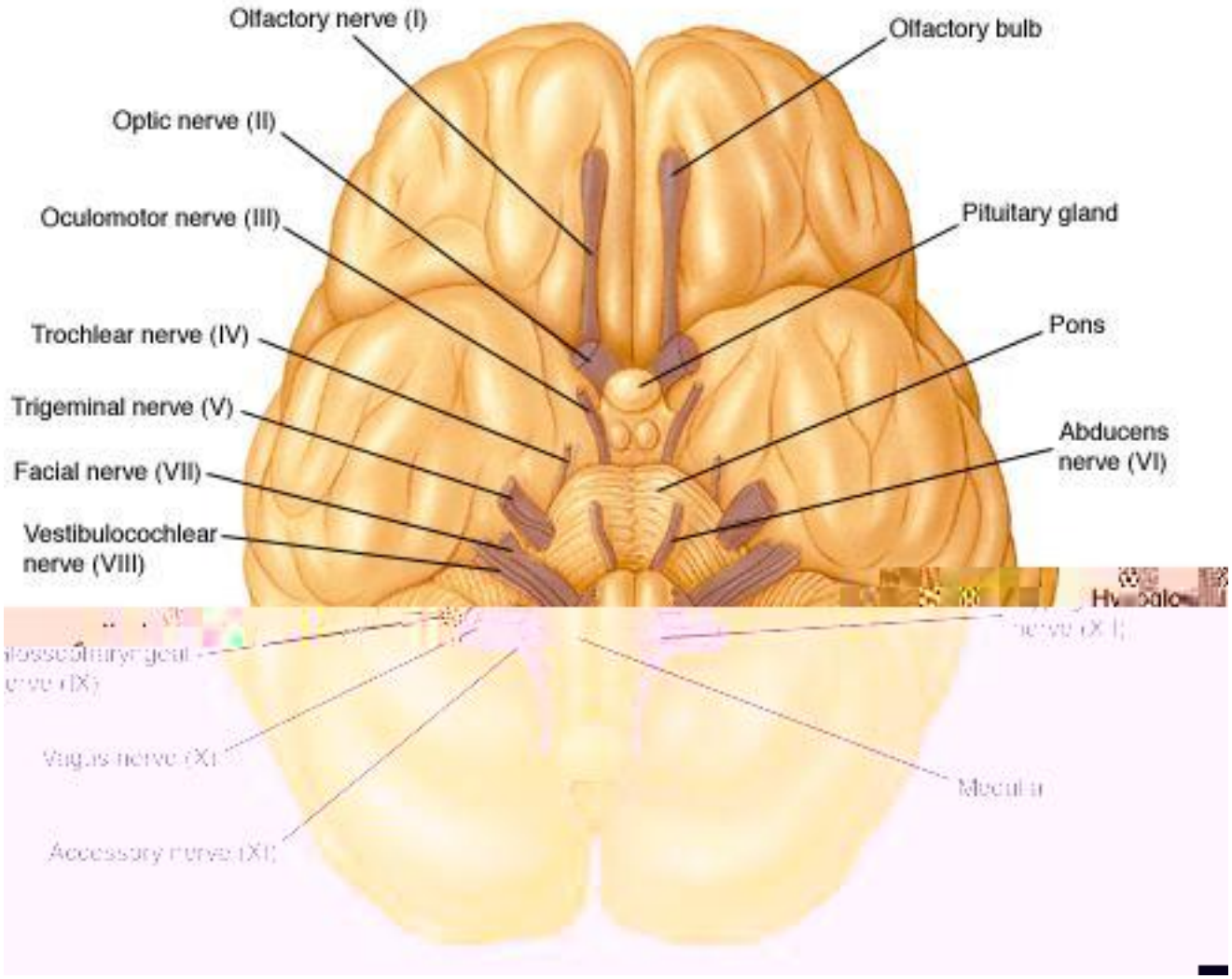




Inferior Nasal Conchae- scroll-like bones that project into the nasal cavity inferior to the superior and middle nasal conchae of the ethmoid bone.


Olfactory Bulbs
No Vomeronasal Nerves?
?
Vomeronasal Organ
Olfactory Mucosa


Frontal sinus
Olfactory bulb
Anterior ethmoidal nerve
Septal olfactory nerves
Internal nasal branches of anterior ethmoidal nerve
Pterygopalatine ganglion (in pterygoid canal)
Nasal Septum
Nasopalatine nerves
Greater palatine nerve
Lesser palatine nerve


Olfactory nerve (I)
Olfactory bulb
Optic nerve (II)
Oculomotor nerve (III)
Pituitary gland
Trochlear nerve (IV)
Pons
Trigeminal nerve (V)
Abducens nerve (VI)
Facial nerve (VII)
Vestibulocochlear nerve (VIII)
Vagus nerve (X)
Medulla
Accessory nerve (XI)

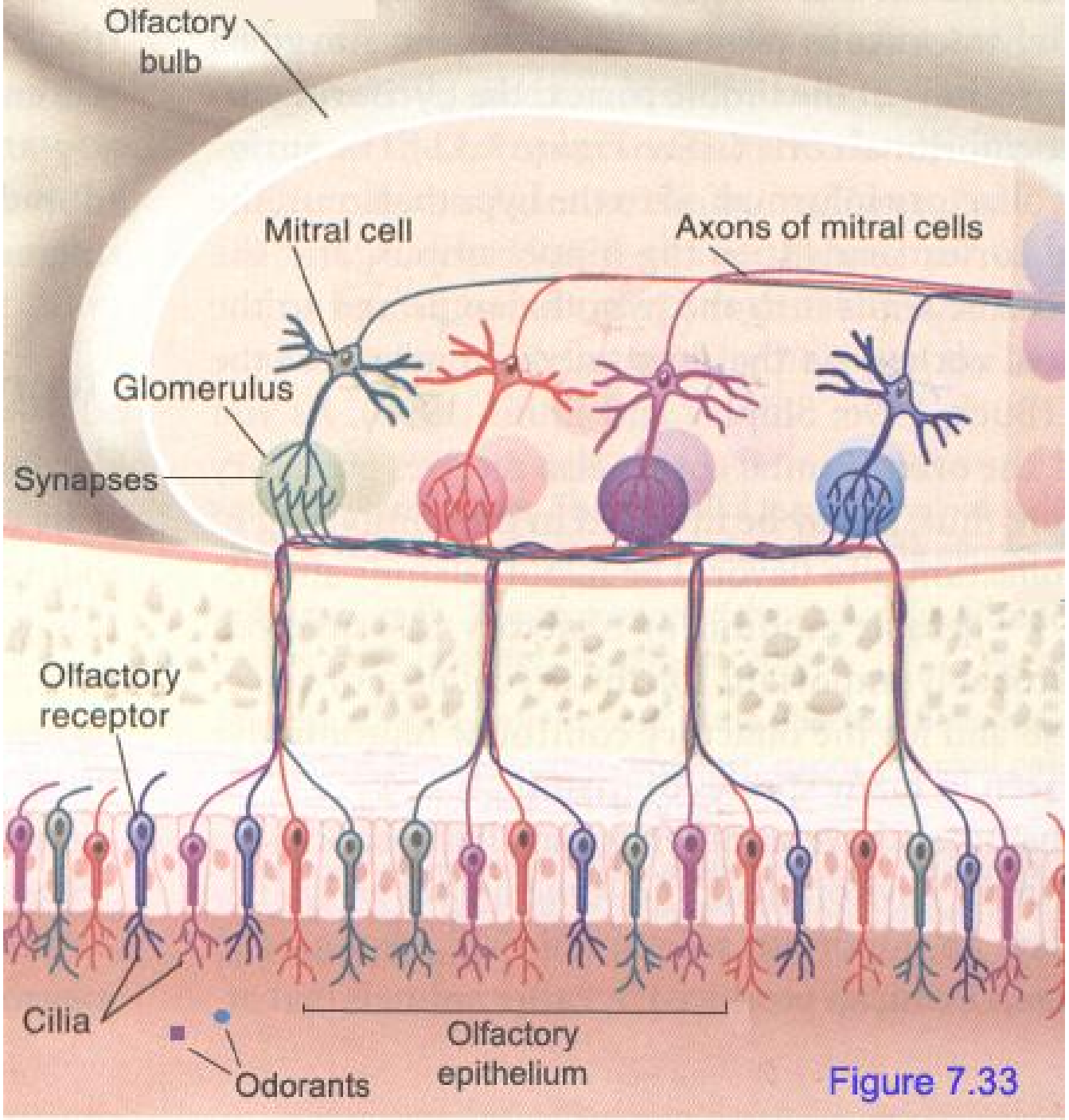
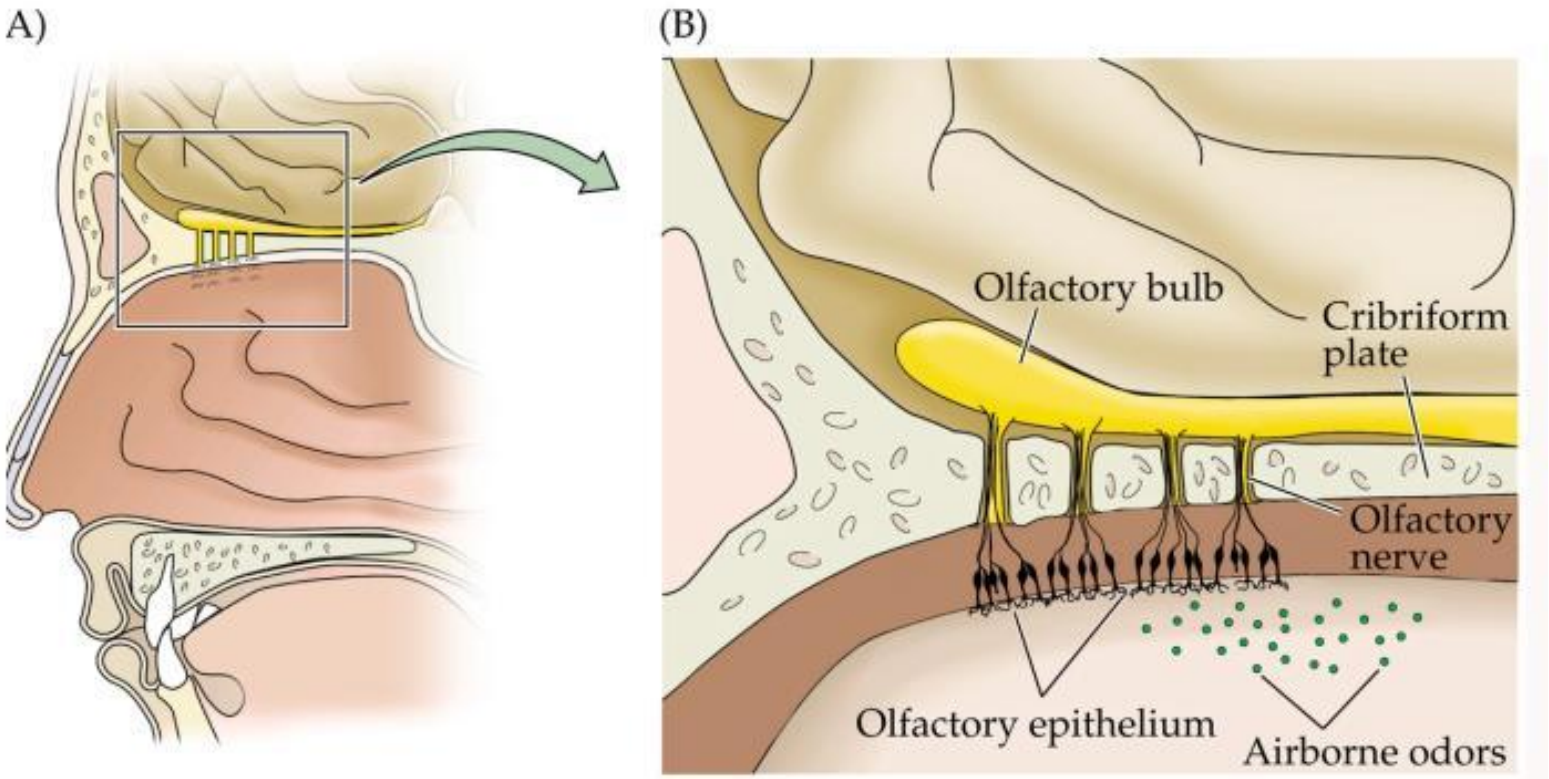
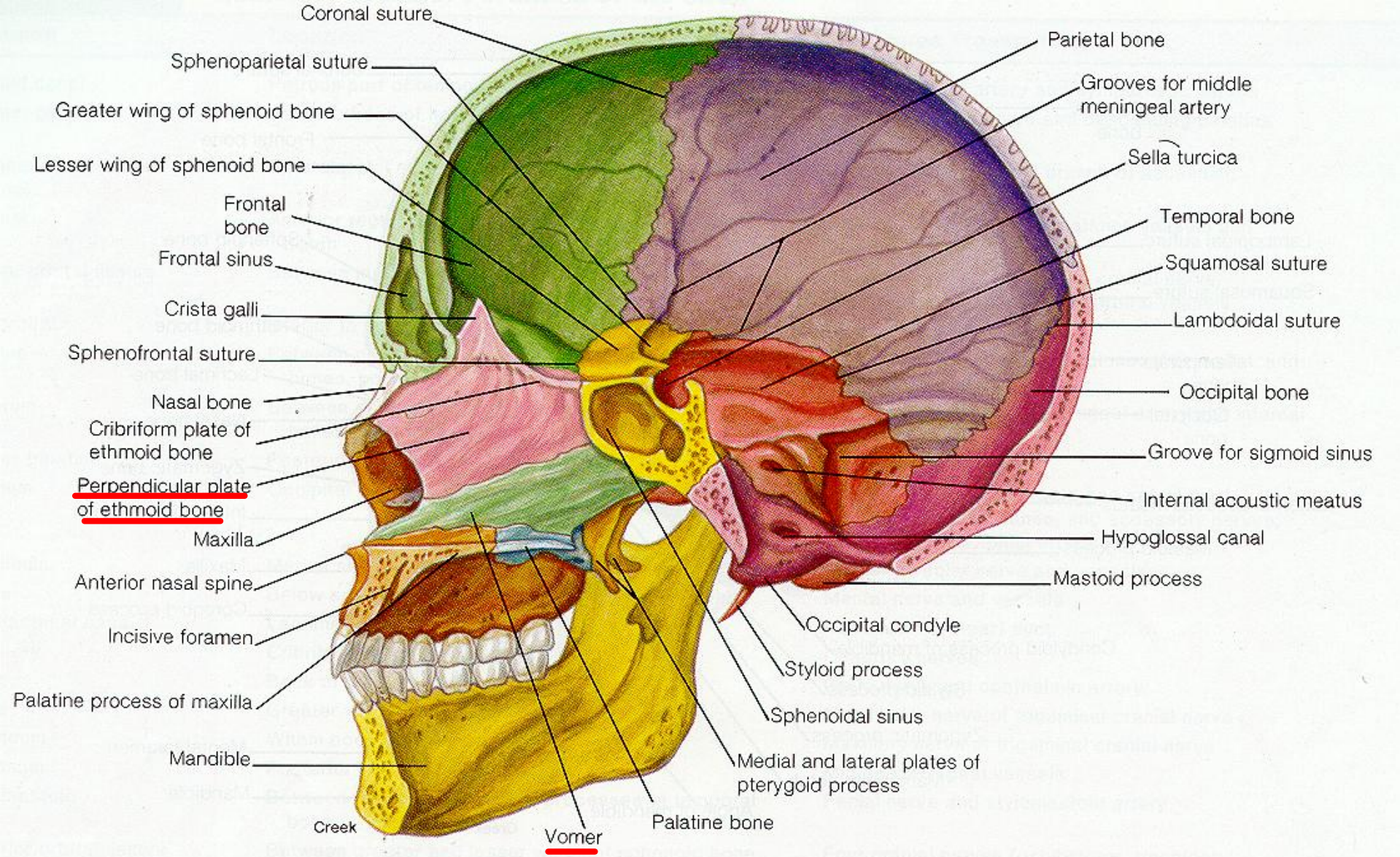

Olfactory bulb
Mitral cell
Axons of mitral cells
Glomerulus
Synapses
Olfactory receptor
Cilia
Odorants
Olfactory epithelium

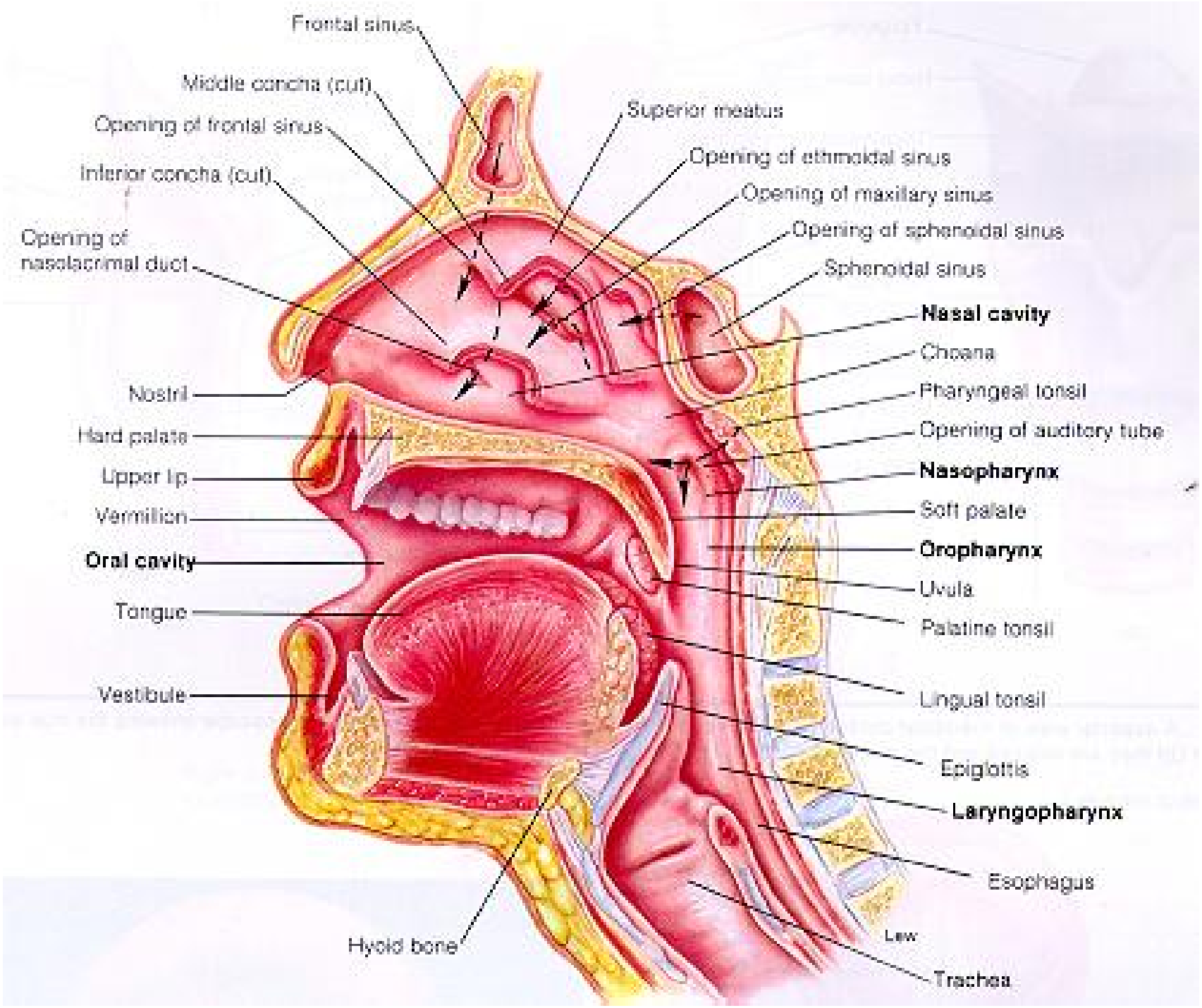
Figure 7.33

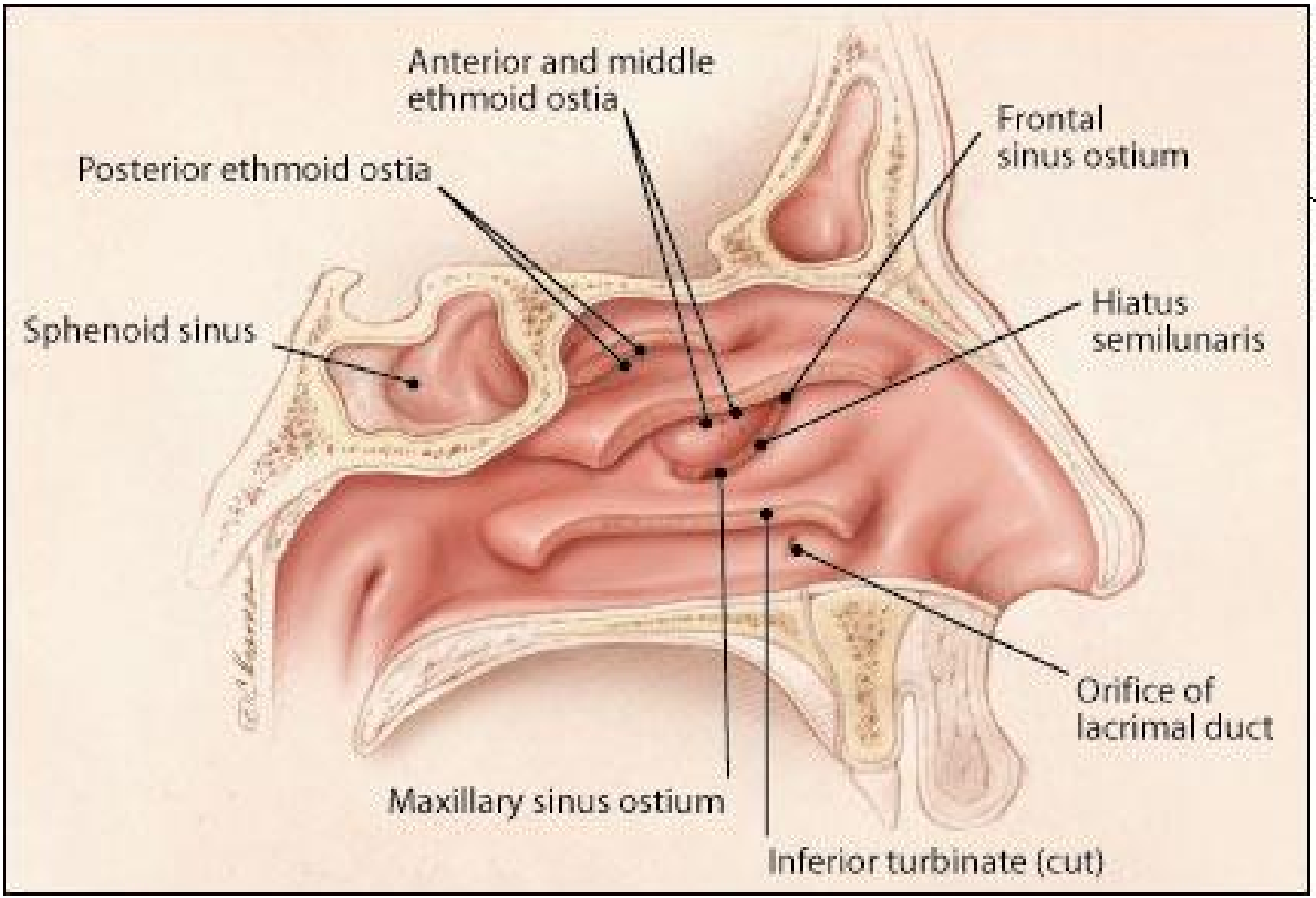
Olfactory system





Vomer- triangular shaped bone that forms the lower and back part of the nasal septum. The nasal septum is composed of three structures: perpendicular plate of the ethmoid bone, vomer, and the septal cartilage. A deviated septum may cause partial or complete blockage of the nasal passage leading to nasal congestion, blocked paranasal sinuses, chronic sinusites, headaches, or nose bleeds.


Frontal sinus
Middle concha (cut)
Opening of frontal sinus
Inferior concha (cut)
Opening of nasolacrimal duct
Nostril
Hard palate
Upper lip
Vermilion
Oral cavity
Tongue
Vestibule
Hyoid bone
Superior meatus
Opening of ethmoidal sinus
Opening of maxillary sinus
Opening of sphenoidal sinus
Sphenoidal sinus
Nasal cavity
Choana
Pharyngeal tonsil
Opening of auditory tube
Nasopharynx
Soft palate
Oropharynx
Uvula
Palatine tonsil
Lingual tonsil
Epiglottis
Laryngopharynx
Esophagus
Larynx
Trachea



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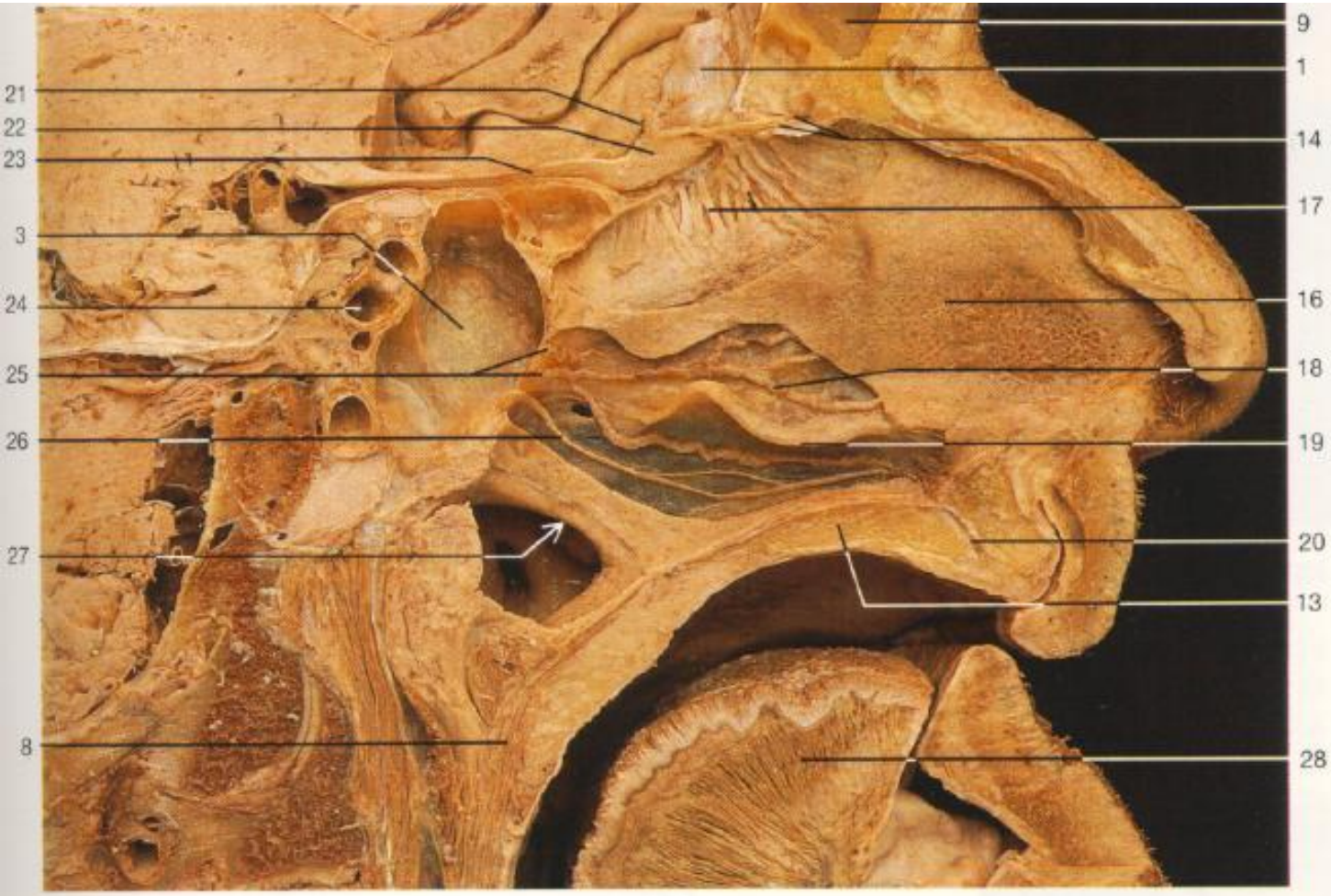
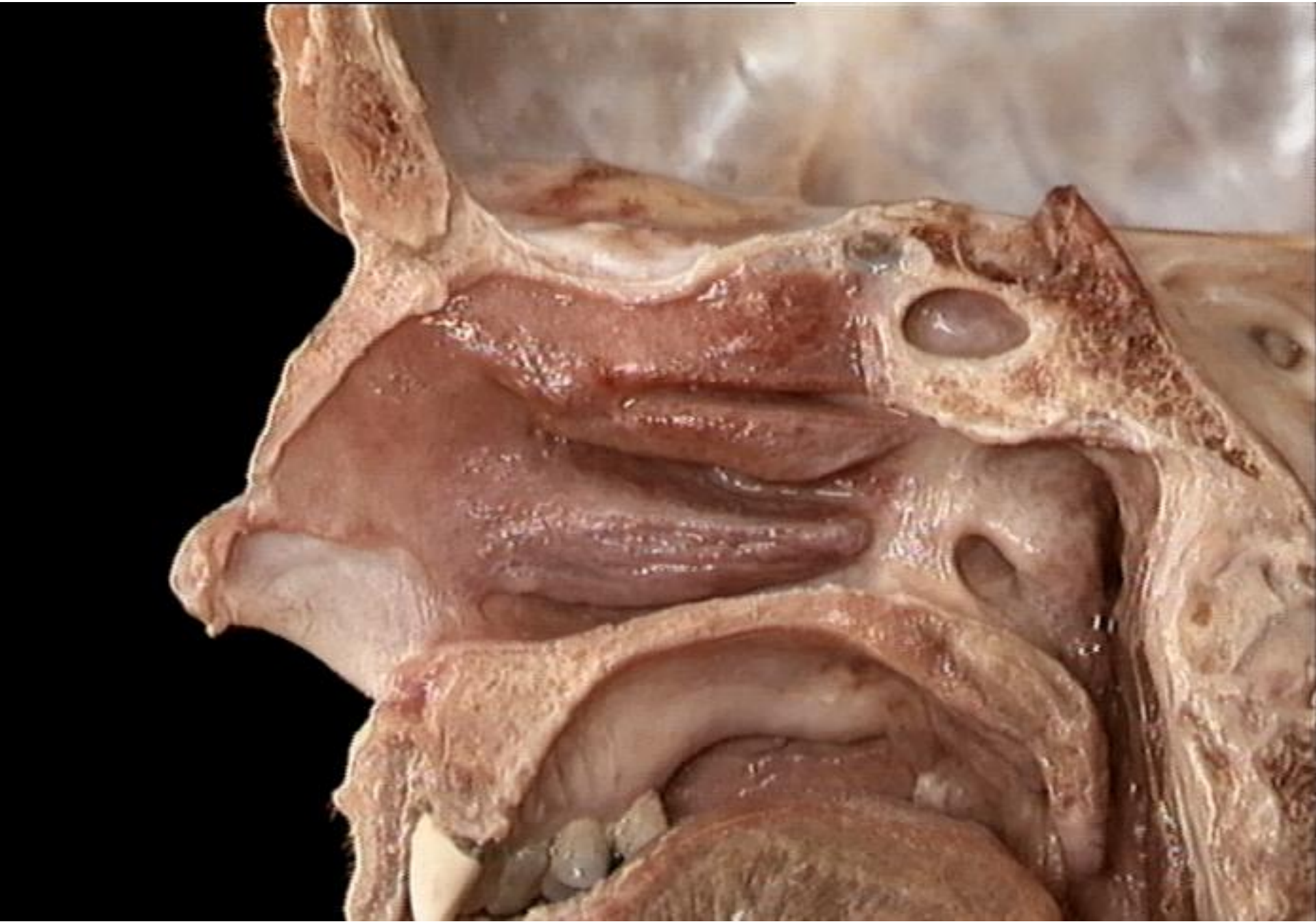
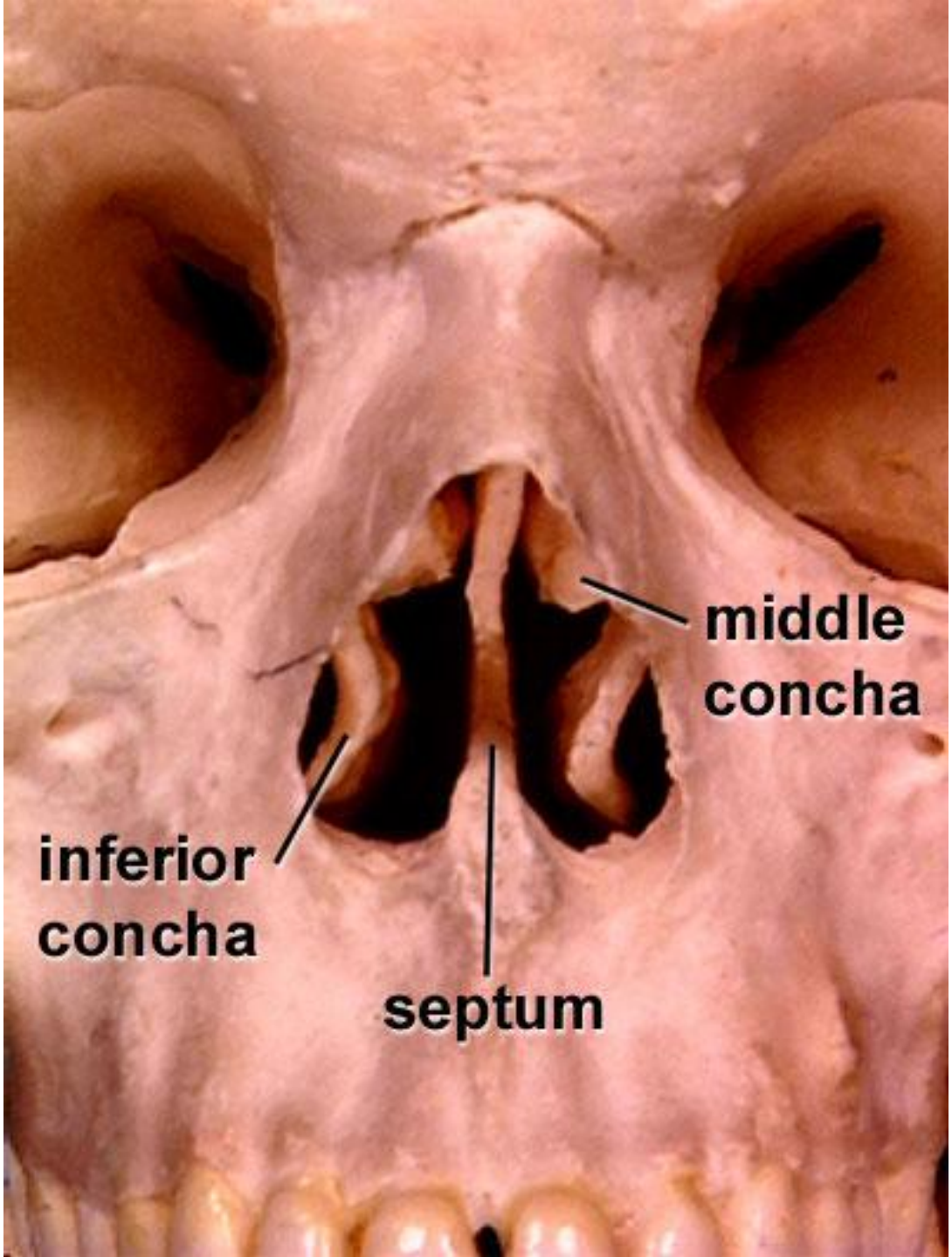
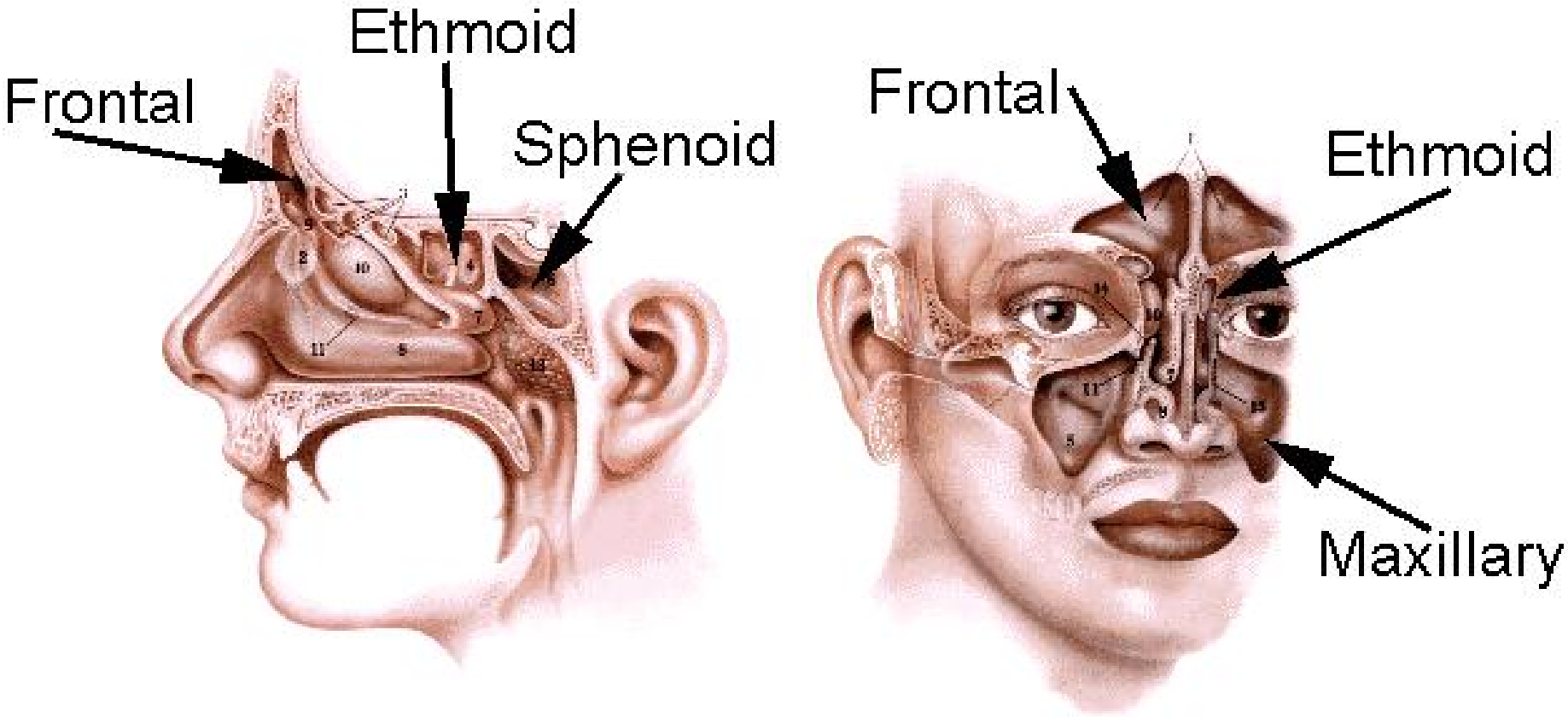


9 Frontal sinus
10 Perpendicular plate of ethmoid
11 Cartilage of nasal septum
12 Vomer
13 Hard palate
14 Nasal branch of anterior ethmoidal artery and anterior ethmoidal nerve
15 Epipharynx
16 Nasal septum
17 Olfactory nerves
18 Septal artery
19 Crest of nasal septum
20 Incisive canal
21 Anterior ethmoidal artery
22 Olfactory bulb
23 Olfactory tract
24 Internal carotid artery
25 Posterior nasal and septal arteries
26 Nasopalatine nerve
27 Choana
28 Tongue

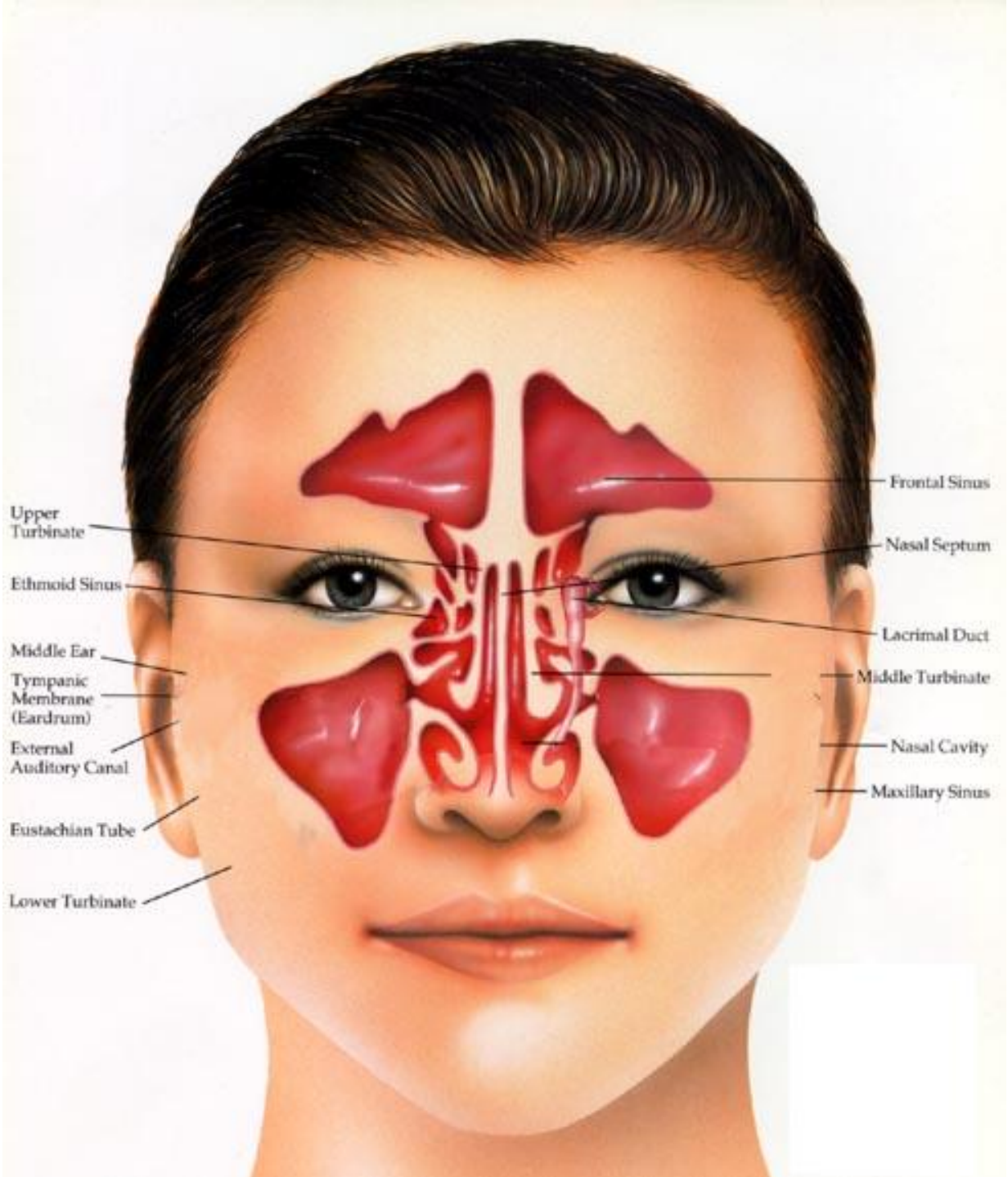
Nasal septum. Dissection of nerves and vessels.




middle
concha
inferior
concha
septum



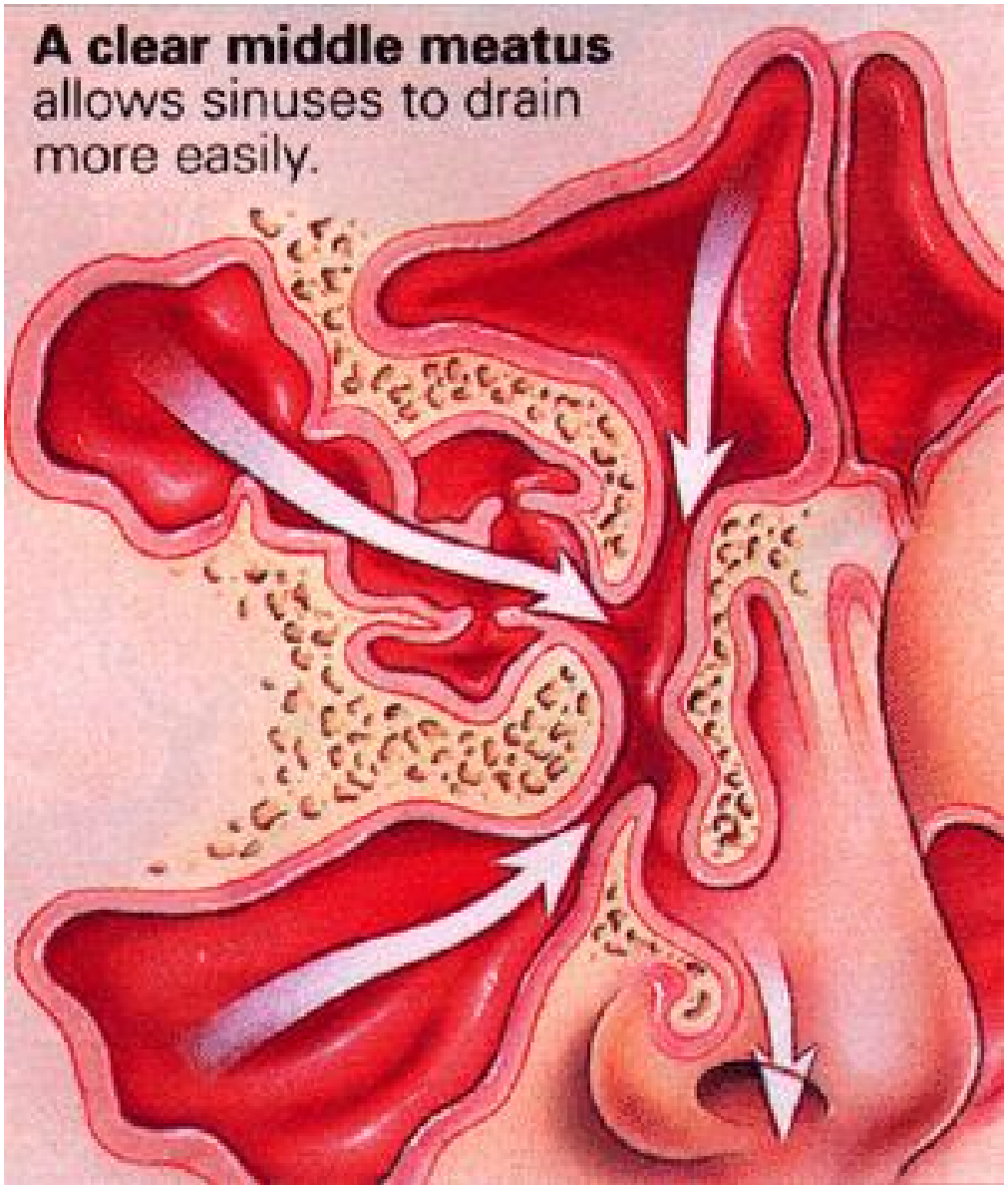
The maxillary, ethmoid, frontal and sphenoid sinuses. Note that the frontal and sphenoid sinuses are not well developed in young children.

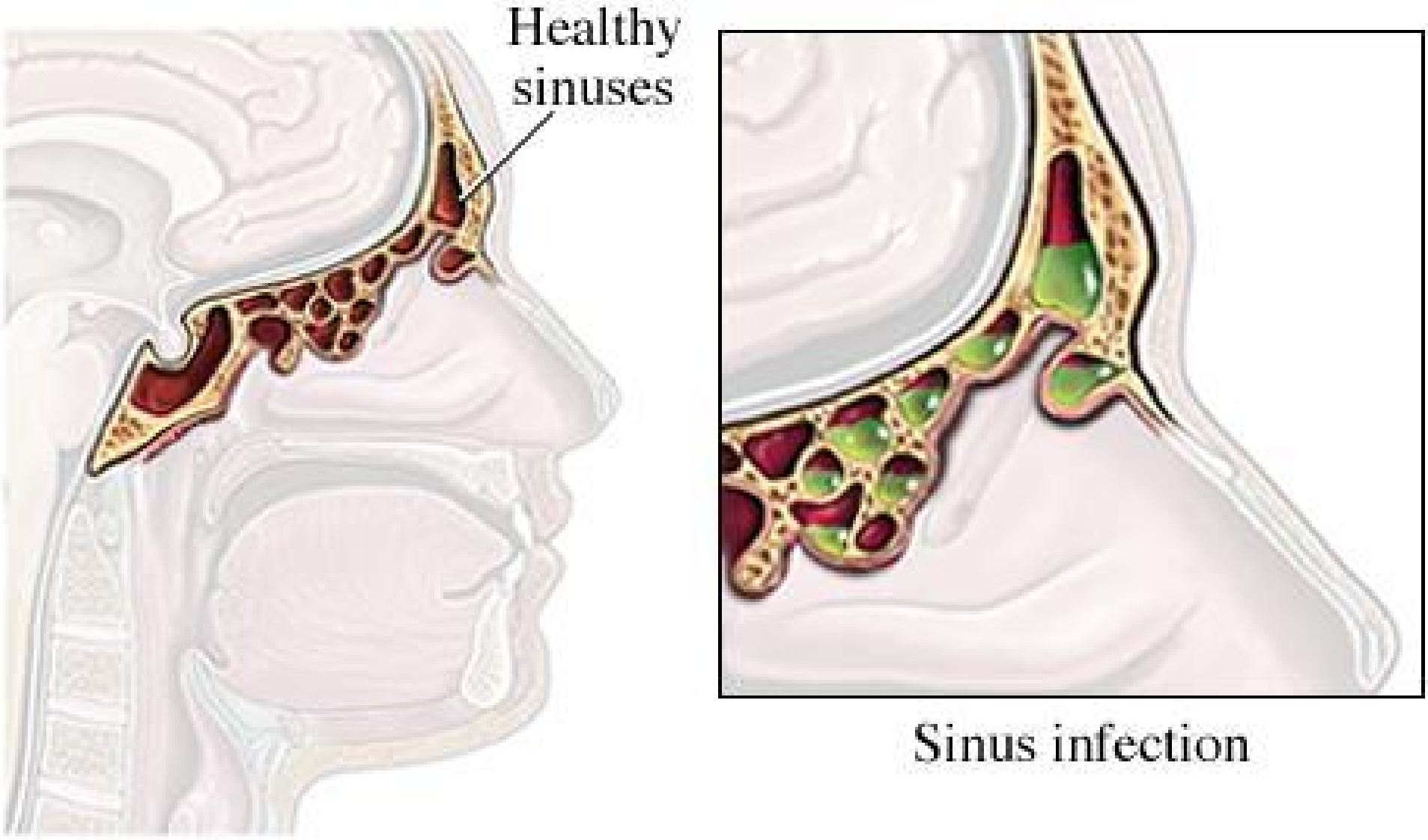

Upper Turbinate
Ethmoid Sinus
Middle Ear
Tympanic Membrane (Eardrum)
External Auditory Canal
Eustachian Tube
Lower Turbinate
Frontal Sinus
Nasal Septum
Lacrimal Duct
Middle Turbinate
Nasal Cavity
Maxillary Sinus

Sinusitis

- Sinusitis starts as a result of blockage of the drainage pathway of the sinuses. This blockage can occur as a result of
  - an anatomical obstruction,
  - swelling due to a cold or allergy,
  - or chronic recurrent sinus infections.
- When this occurs, mucus that normally is expelled from the sinus builds up in the sinus.
  - cause pressure or pain
  - mucus is an excellent culture medium for bacteria
- If the mucus is not cleared immediately, a bacterial infection exists until the blockage is cleared and the sinuses drain normally again.

Normal Sinus Drainage

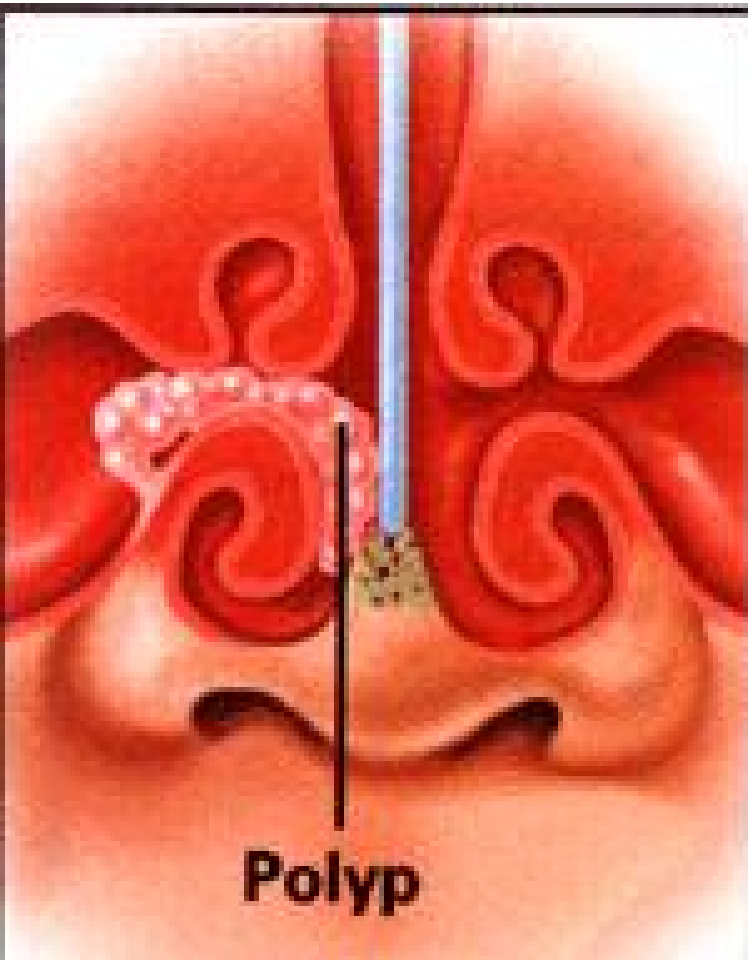




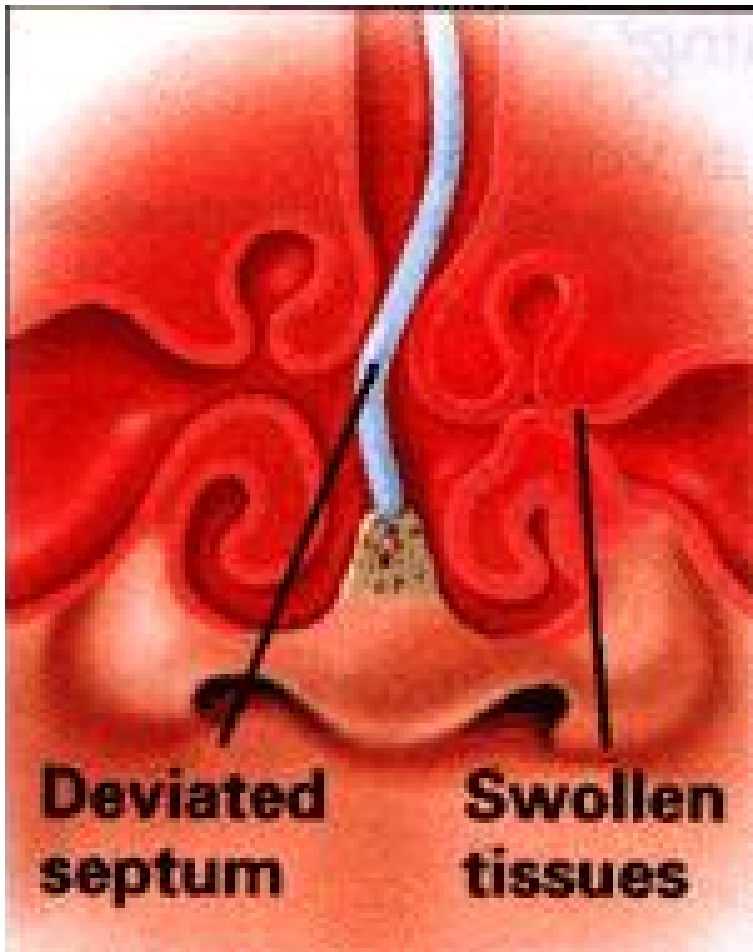
Sinus infection

Block Sinus Drainage Resulting in Sinusitis

Nasal Polyp Obstructing the Sinuses



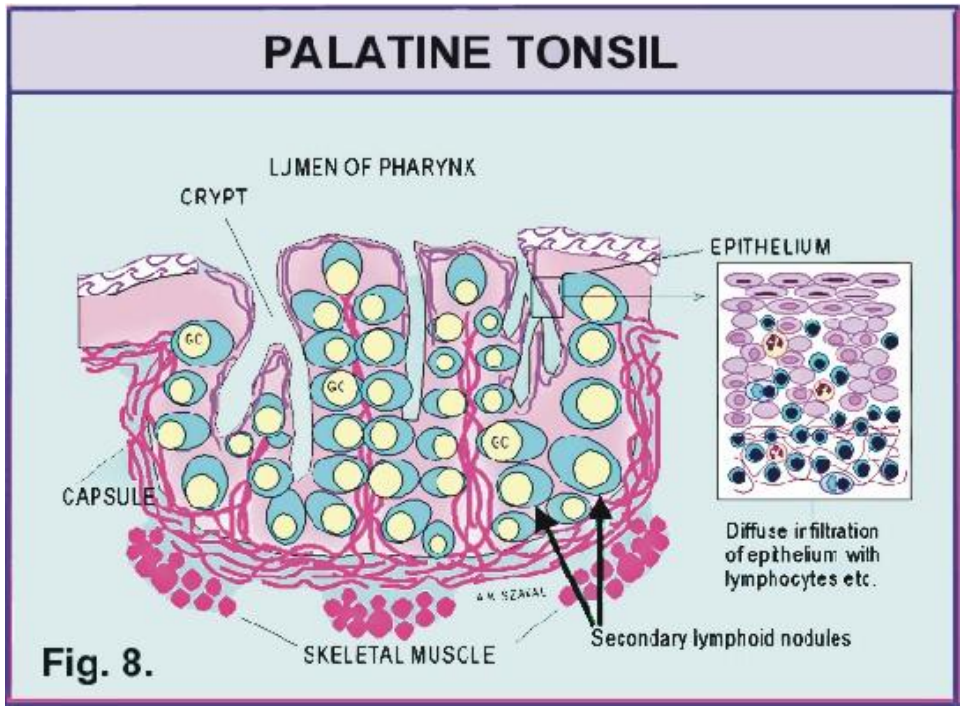
Deviated Septum Obstructing the Sinuses



Post Nasal Drip

- When excess mucous produced in the sinus cavities drips down the back of the throat.
- Excess mucous, once settled on your nasal and throat lining, can irritate, causing a sore throat, and the belief that you may be coming down with a cold.
- Excess mucous production or Post Nasal Drip (PND) will directly affect your breath as it is high in proteins and is an excellent food source for anaerobic bacteria.

Small white or yellow crystals lodged in your tonsils.



- If you have excess mucous this will cause an increase of anaerobic bacteria. These bacteria feed on the mucous as it is high in protein. They then make condensed sulphur granules called TONSILLOLITHS which are laid down in the back of the throat. Every time your tongue touches the back of the throat when you swallow, it will carry these Tonsilloliths into the crypts or folds of the tonsils. If you have ever picked these out with a Q tip you will notice the foul smell that they have. Tonsilloliths are not only a sign of post nasal problems, but also a sign of bad breath.

Signs of Post Nasal Drip

- Bad Breath
- Needing to clear your throat
- Constantly swallowing or feel that you have something trapped in the back of your throat.
- Continual sore throats that do not develop into illness.
- Small white or yellow crystals lodged in your tonsils.
- Nasal and Sinus Congestion

Causes of PND

- Inhaled Irritants - swelling of the nasal and sinus linings
- Dairy Products- cause mucous to thicken dramatically. This can then inhibit proper drainage.
- Allergies to foods- These will once again thicken mucous, and inhibit proper drainage.
- Illnesses- as flu, colds, bronchitis, ear infections and tonsillitis are the main culprits in post nasal drip and excess mucous
- Asthma- excess mucous

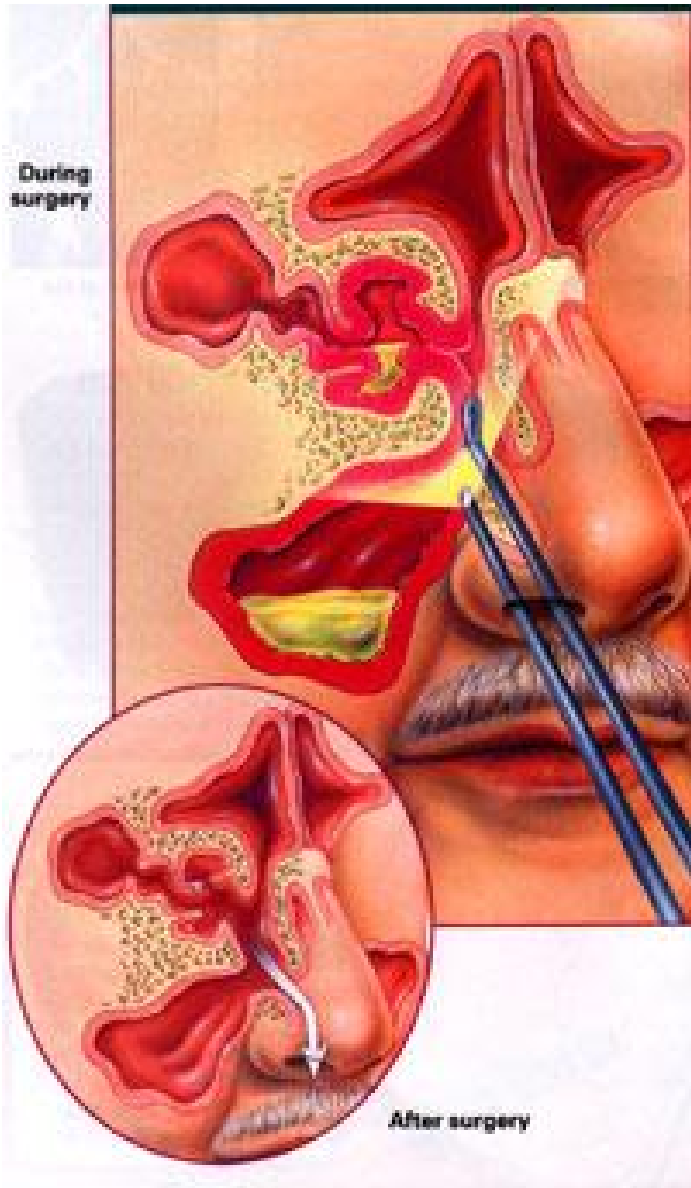
Functional Endoscopic Sinus Surgery (FESS)

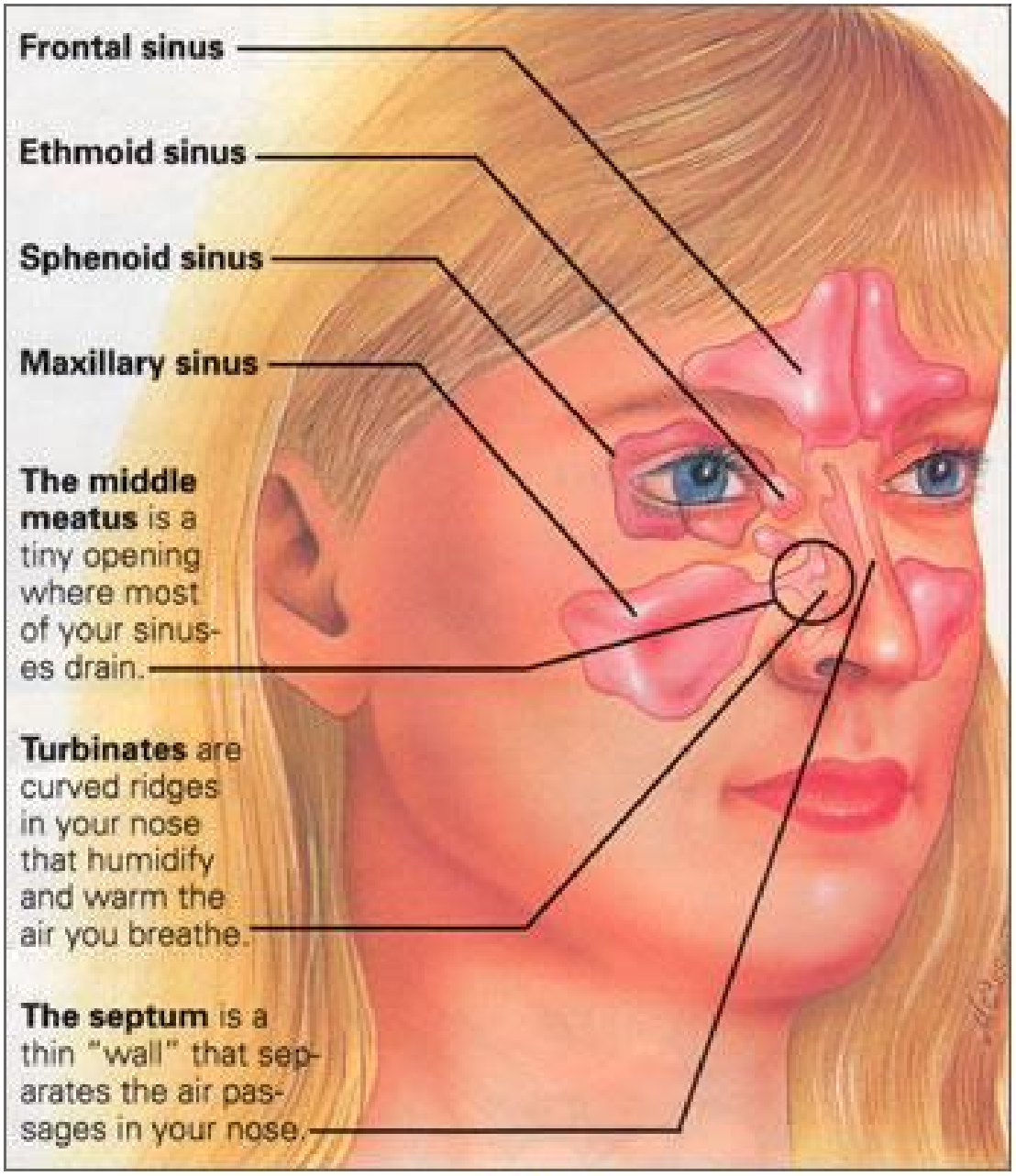
• Straightening the septum (the bone and cartilage separating the two sides of your nose),

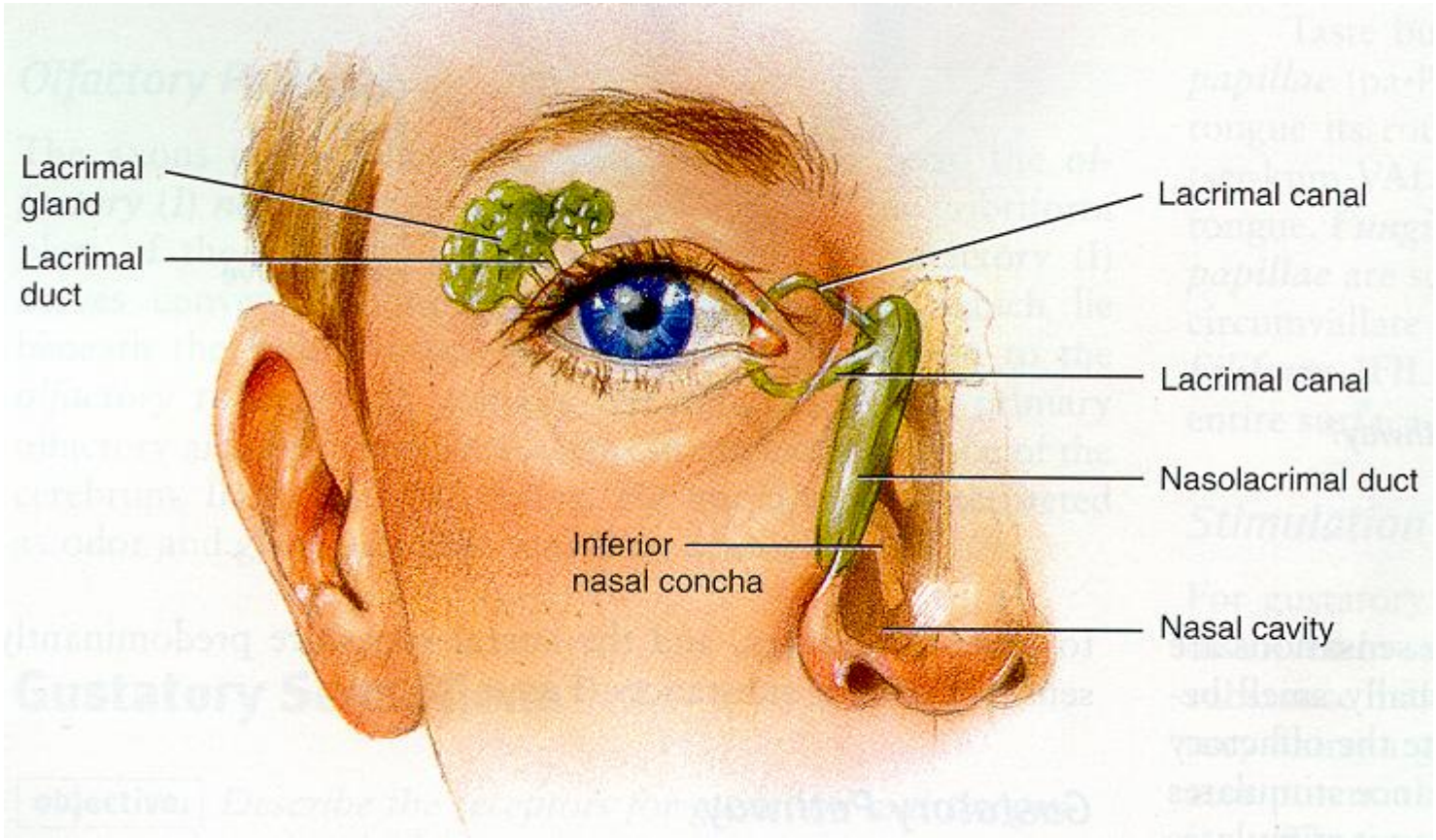
• Removing tissue from inside the nose

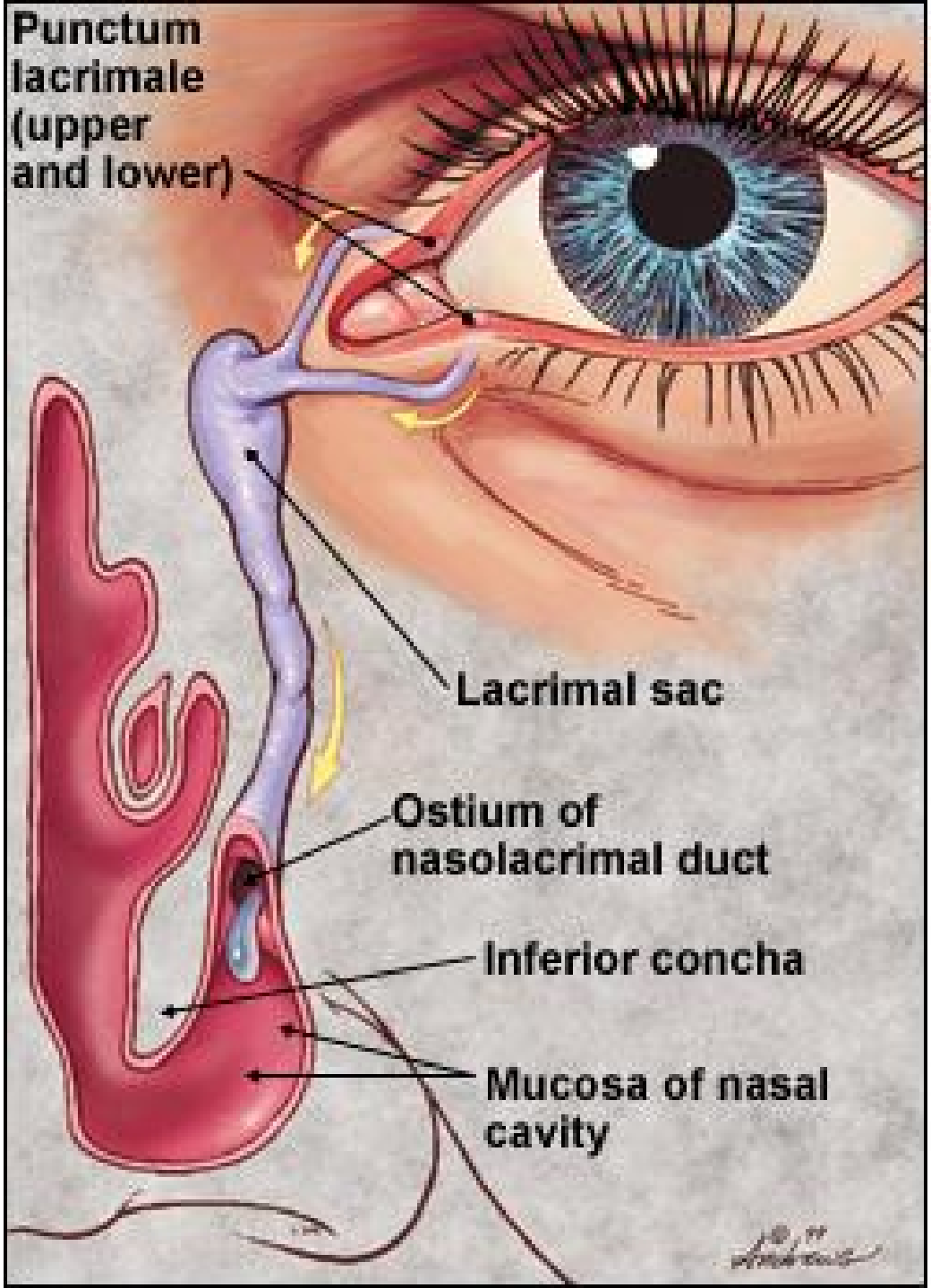
• Making an opening into the sinus(es) on either side of the nose so that drainage can occur more effectively, and

• Remove some of the lining of the sinuses for biopsy if indicated..




Frontal sinus
Ethmoid sinus
Sphenoid sinus
Maxillary sinus
The middle meatus is a tiny opening where most of your sinuses drain.
Turbinates are curved ridges in your nose that humidify and warm the air you breathe.
The septum is a thin "wall" that separates the air passages in your nose.


Lacrimal gland
Lacrimal duct
Lacrimal canal
Lacrimal canal
Nasolacrimal duct
Inferior nasal concha
Nasal cavity



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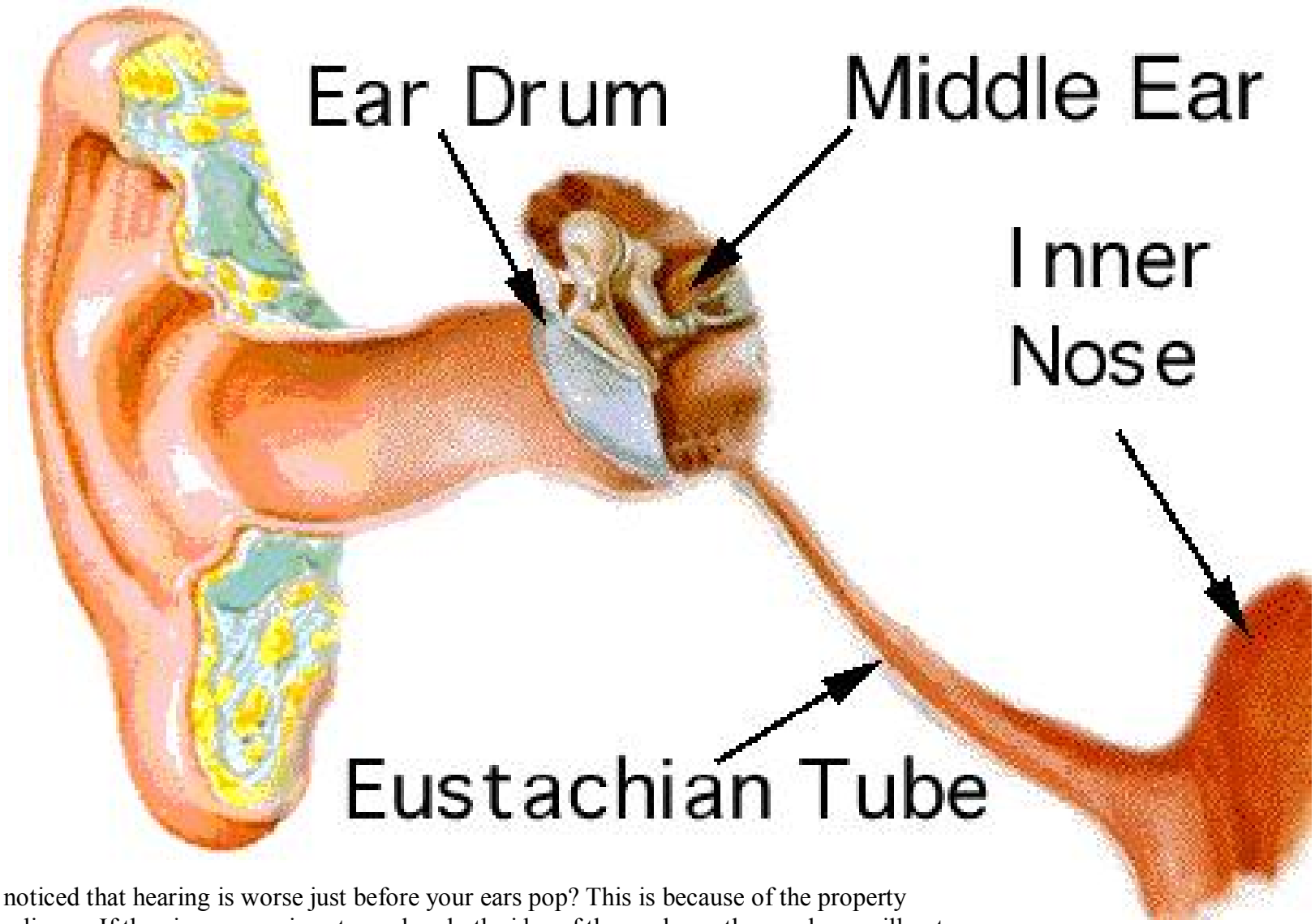
Pharynx (Throat)

- A tube that starts at the internal nares and extends part way down the neck.
- Its walls are lined with skeletal muscle and lined with mucous membrane.
- Functions
  - passageway for air and food
  - resonating chamber for speech sounds

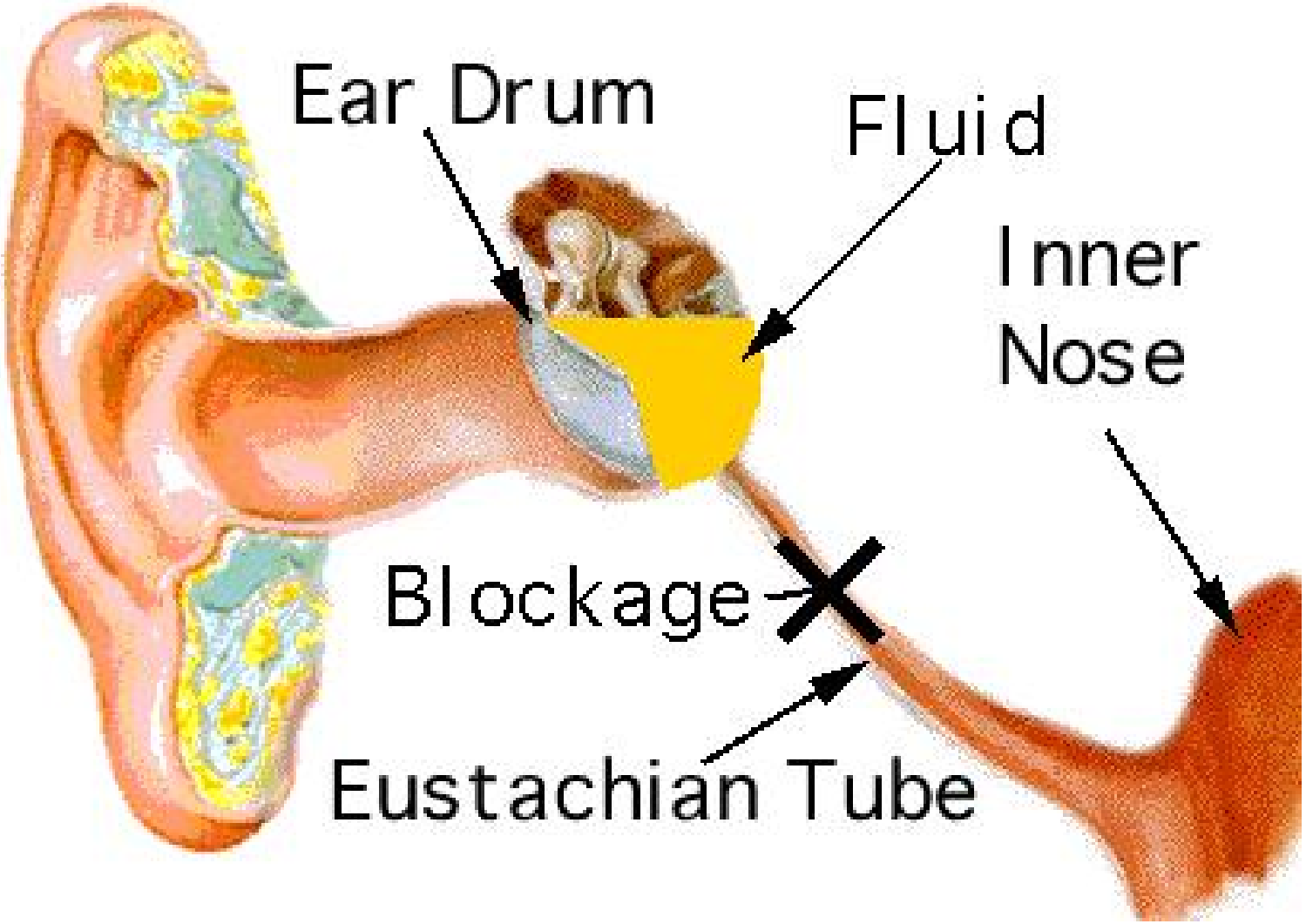
Parts of the Pharynx

Nasopharynx-

- connects with
  - the two internal nares
  - Eustachian tubes- two openings that lead into the ear
  - The single opening into the oropharynx
- The posterior wall contains the pharyngeal tonsil
- It is lined with pseudostratified ciliated columnar epithelium, and
  - the cilia moves the dust laden mucous toward the mouth.
- Exchanges a small amount of air with the auditory canal to equalize air pressure between the pharynx and middle ear.

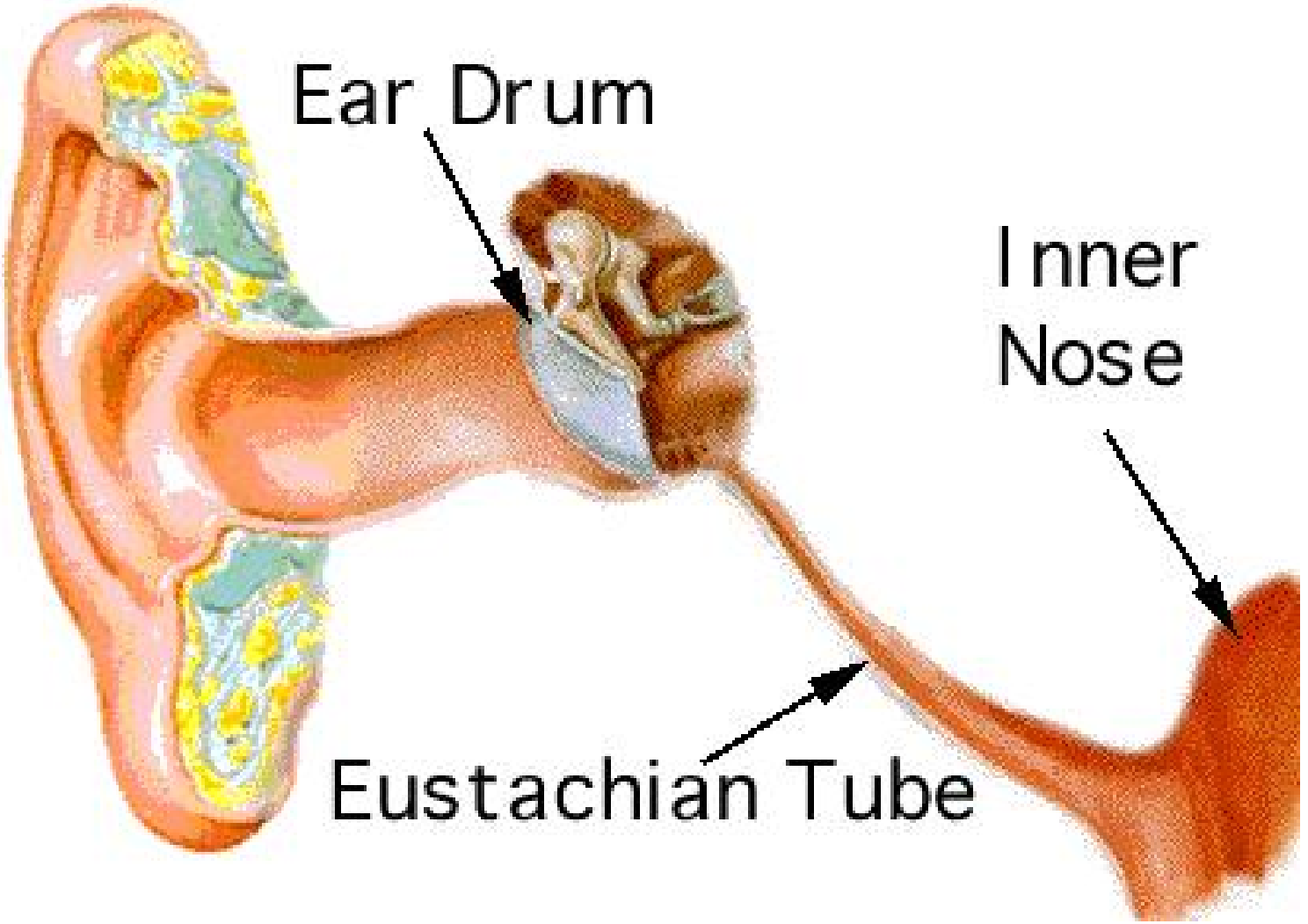


Have you noticed that hearing is worse just before your ears pop? This is because of the property called compliance. If the air pressure is not equal on both sides of the eardrum, the ear drum will not move or vibrate efficiently (reduced compliance). The eustachian tube maintains the optimal compliance by keeping the air pressure outside the ear the same as air pressure inside the ear. The end result is that the eustachian tube preserves and maintains optimal hearing.



When new air is unable to enter the eustachian tube, the body will absorb the remaining air in the middle ear creating a vacuum (negative pressure). This is the same type of pressure that keeps a lid on a Mason Jar. When this pressure is mild, the body senses this as stuffiness or pressure in the ear. However, when the negative pressure is severe the body senses this as pain. If the negative pressure remains for an extended period of time then the body will replace the vacuum with fluid.

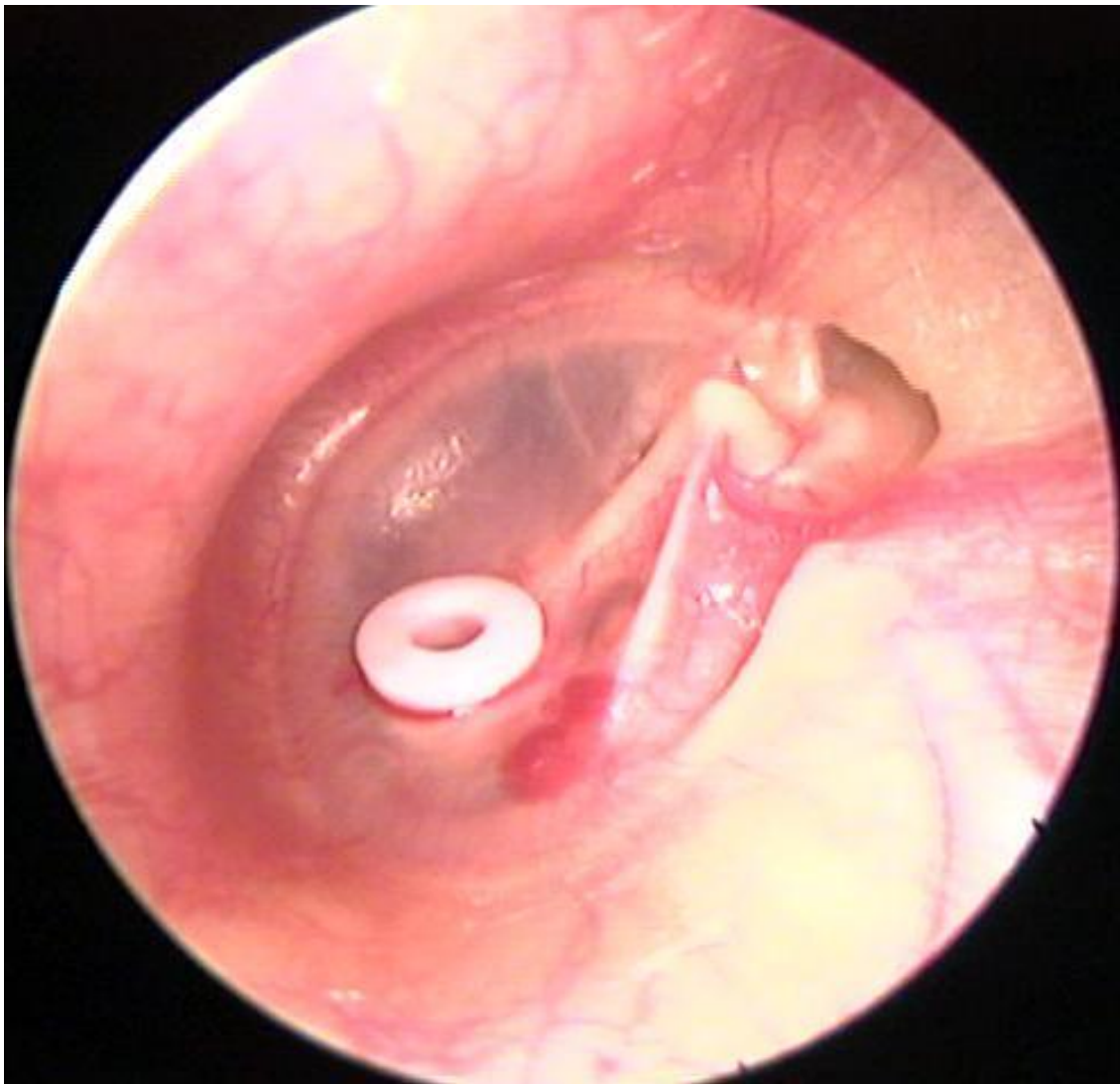
The fluid behind the eardrum can lead to problems with hearing loss and ear infection (otitis). Treatment for middle ear fluid consists of ways to get the air pressure behind the eardrum equal to pressure outside the eardrum. These treatments include inflation of the middle ear via the eustachian tube or if unsuccessful through the eardrum (see placement of pressure equalization tubes)

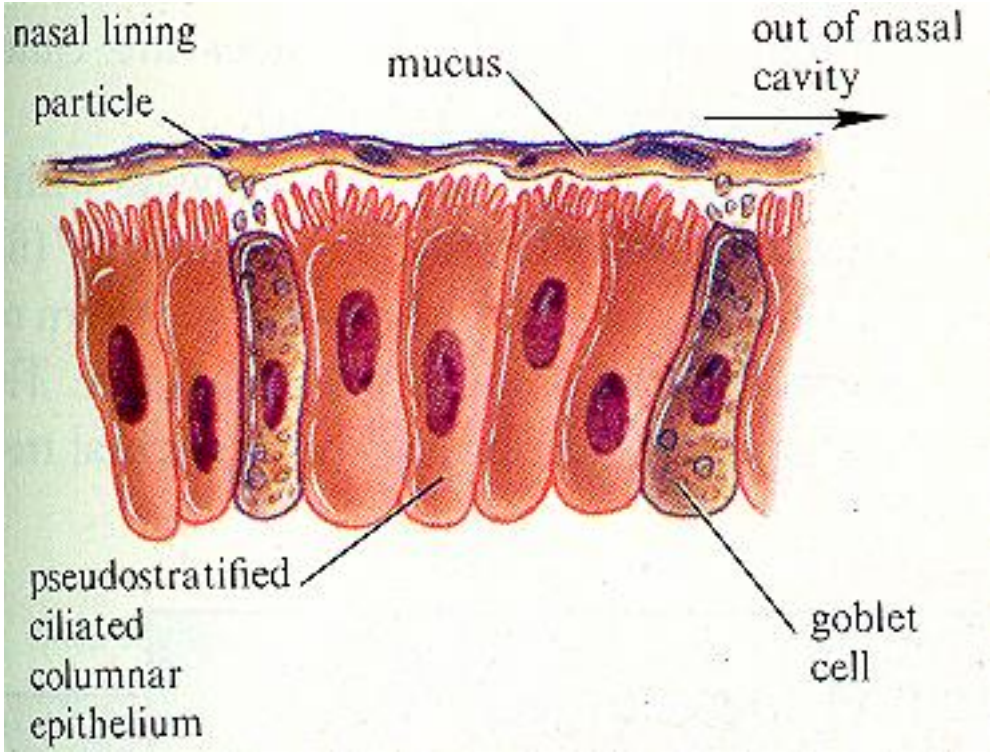


A pressure equalization tube is placed to allow air pressure in the middle ear to equal air pressure in the outside world. In healthy ears, the eustachain tube provides the function of pressure equalization. Without pressure equalization, ear diseases can develop. These problems range from mild hearing loss to life threatening disorders.

Ear tube (Myringotomy Tubes)

Pressure equalizing tubes- allow air to get into the ear space behind the ear drum. Air is needed in this space to allow the ear drum to move.

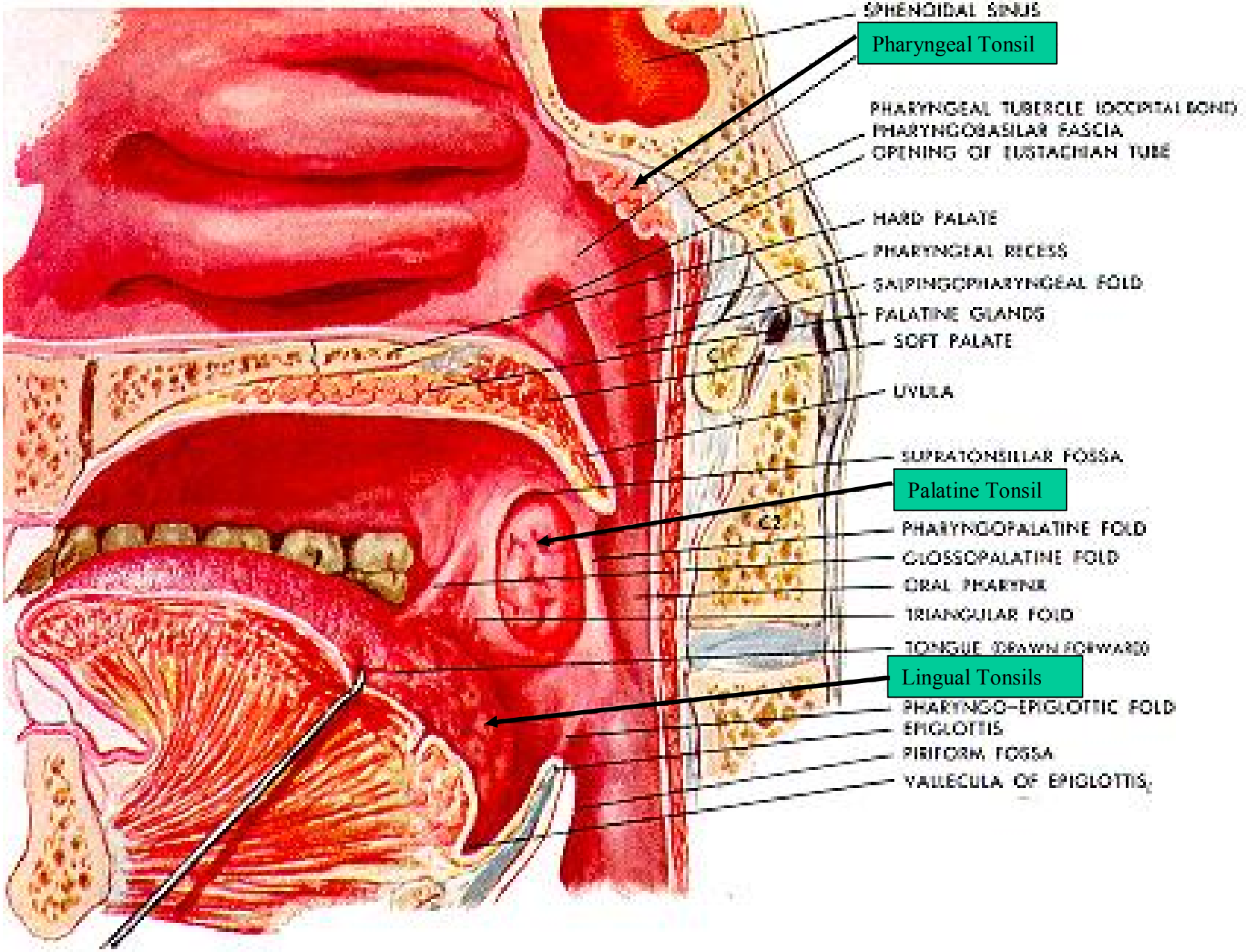


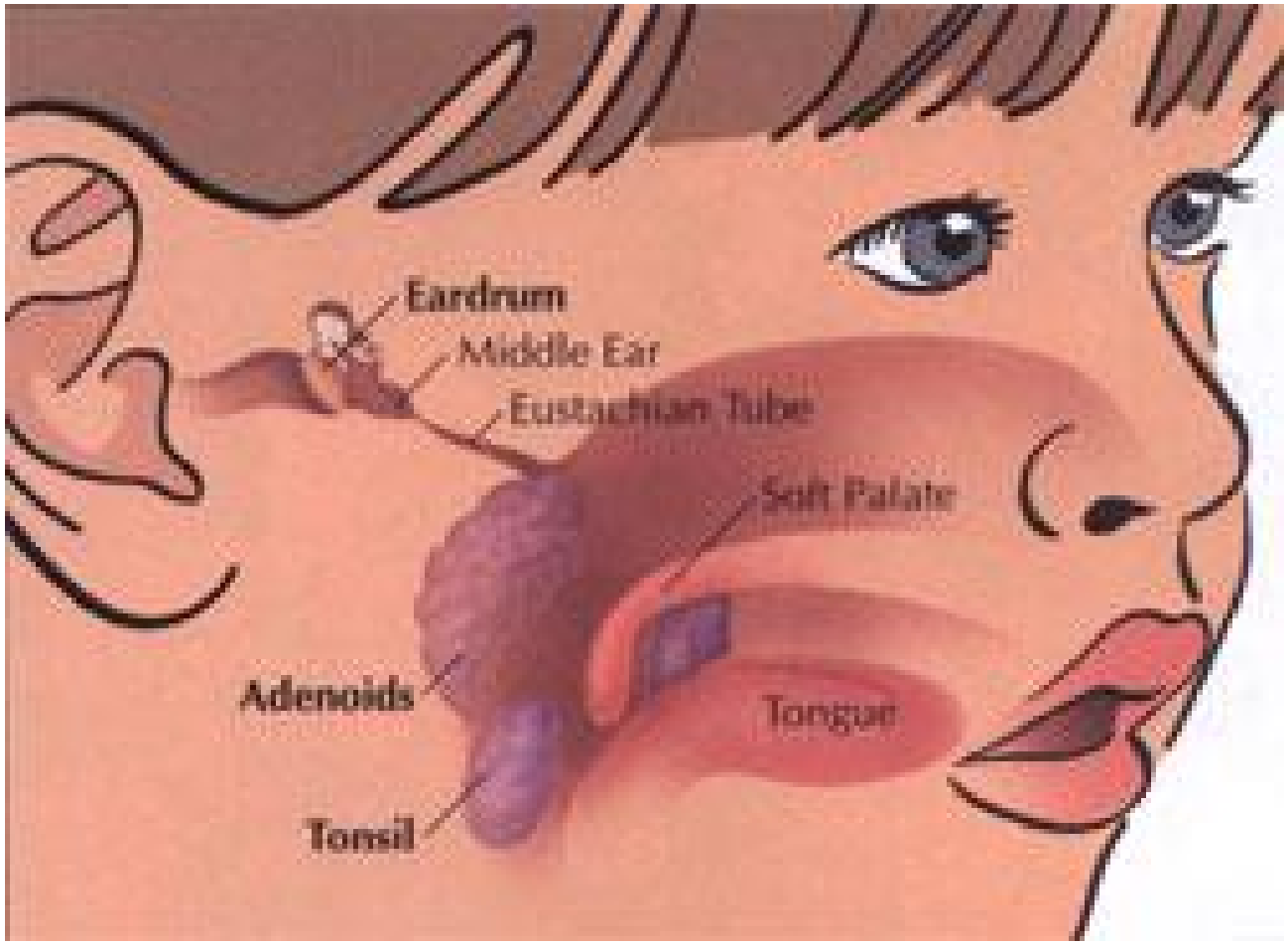

nasal lining
particle
mucus
out of nasal cavity
pseudostratified ciliated columnar epithelium
goblet cell

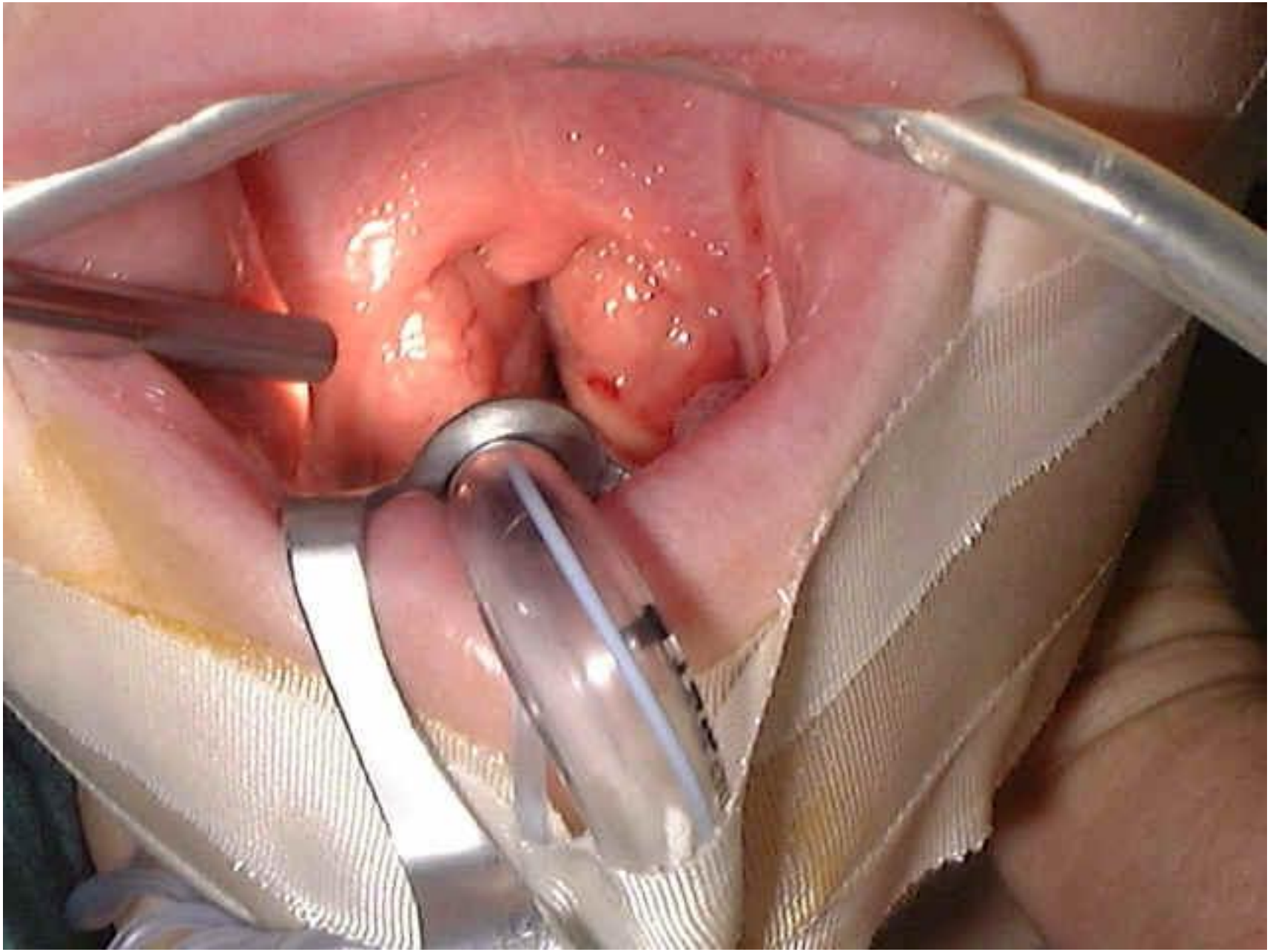
Parts of the Pharynx

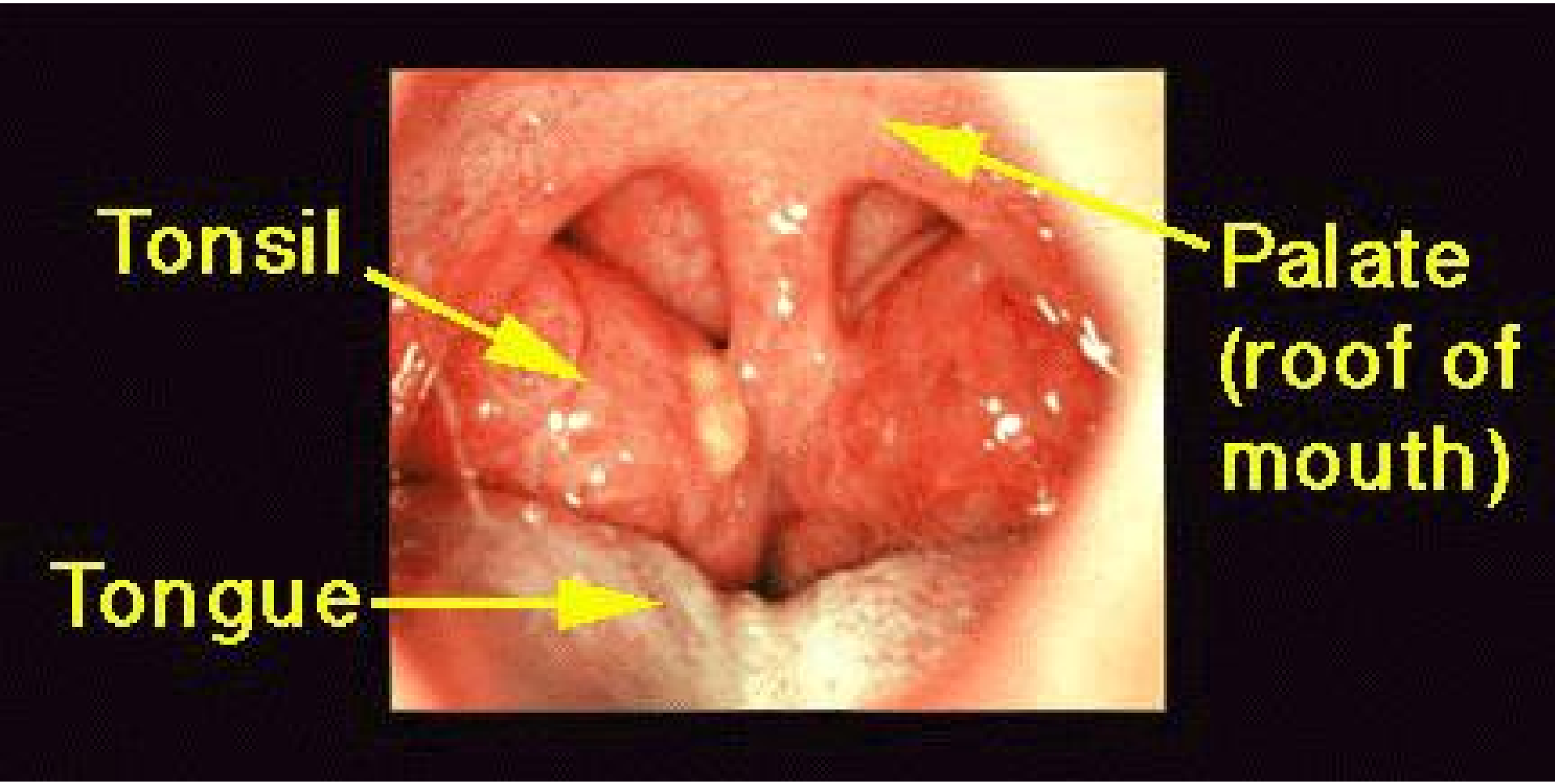
Oropharynx

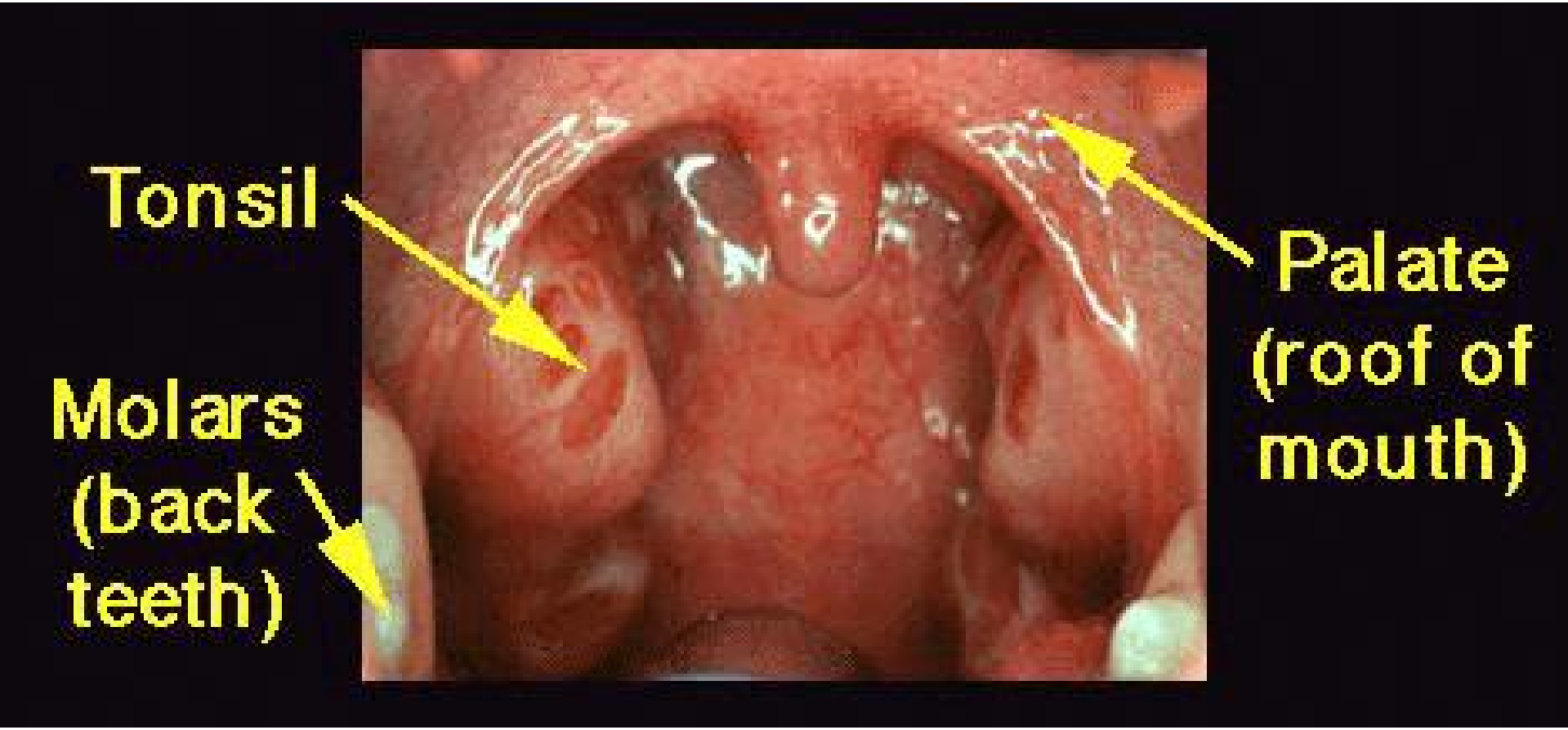
- the middle portion of the pharynx containg the opening from the mouth called the **fauces**.
- Serves as a common passageway for air, food, and drink.
- Lined with nonkeratinized squamous epithelium that's more suitable for abrasion from the coarse food particles.
- Contains the Lingual and Palatine tonsils


SPHENOIDAL SINUS
Pharyngeal Tonsil
PHARYNGEAL TUBERCLE (OCCIPITAL BONE)
PHARYNGOBASILAR FASCIA
OPENING OF EUSTACHIAN TUBE
HARD PALATE
PHARYNGEAL RECESS
SALPINGOPHARYNGEAL FOLD
PALATINE GLANDS
SOFT PALATE
UVULA
SUPRATONSILLAR FOSSA
Palatine Tonsil
PHARYNGOPALATINE FOLD
GLOSSOPALATINE FOLD
ORAL PHARYNX
TRIANGULAR FOLD
TONGUE (DRAWN FORWARD)
Lingual Tonsils
PHARYNGO-EPIGLOTTIC FOLD
EPIGLOTTIS
PIRIFORM FOSSA
VALLECULA OF EPIGLOTTIS


Eardrum
Middle Ear
Eustachian Tube
Soft Palate
Adenoids
Tongue
Tonsil



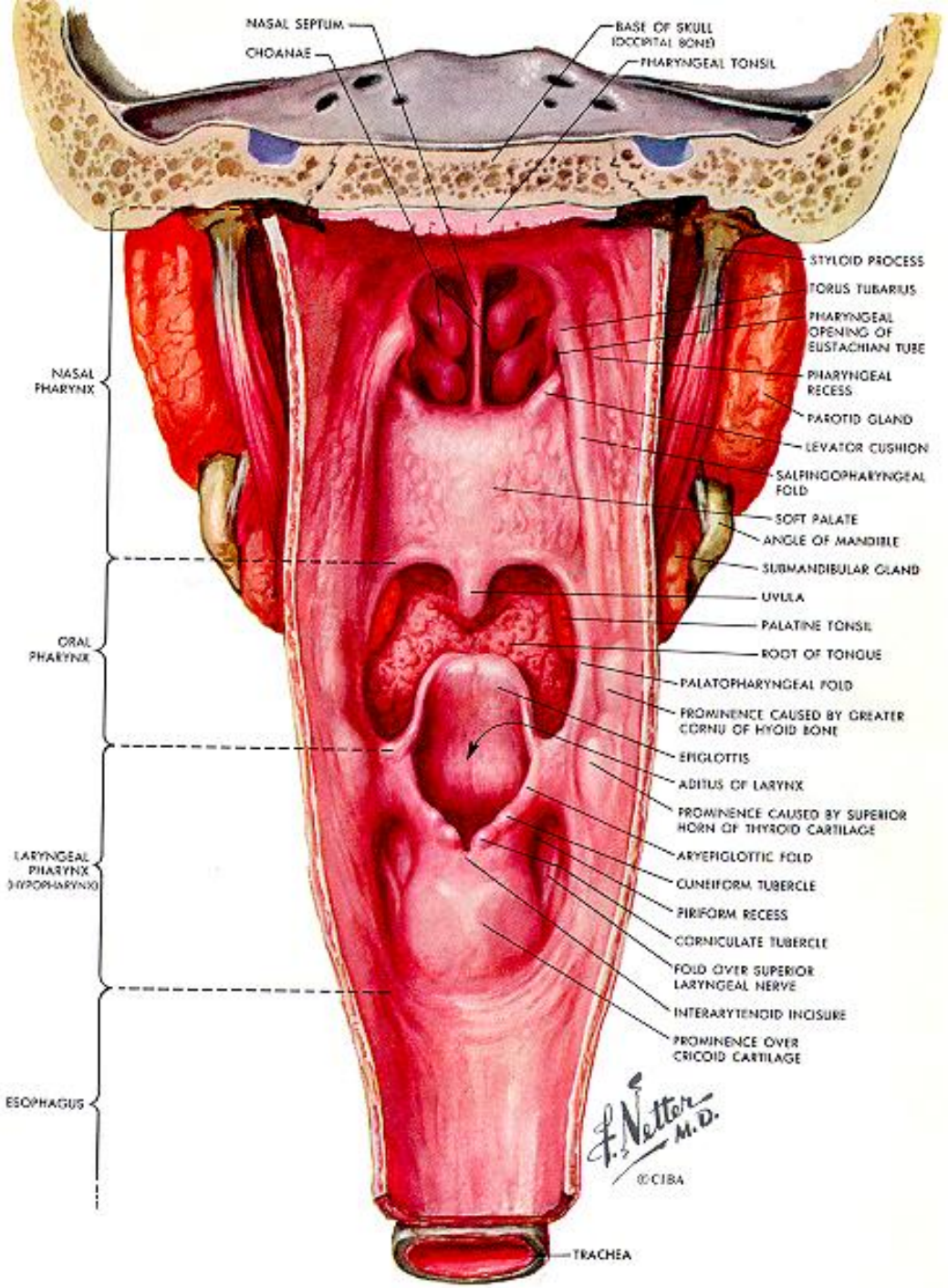

Tonsil
Palate
(roof of
mouth)
Tongue


Tonsil
Molars (back teeth)
Palate (roof of mouth)

Parts of the Pharynx

Laryngopharynx

- Extends downward from the hyoid bone and connects with the esophagus (food tube) in back and the larynx (voice box) in front.
- Lined with nonkeratinized squamous epithelium.
- Has both respiratory and digestive function.


NASAL SEPTUM
CHOANAE
BASE OF SKULL (OCCIPITAL BONE)
PHARYNGEAL TONSIL
STYLOID PROCESS
TORUS TUBARIUS
PHARYNGEAL OPENING OF EUSTACHIAN TUBE
PHARYNGEAL RECESS
PAROTID GLAND
LEVATOR CUSHION
SALPINGOPHARYNGEAL FOLD
SOFT PALATE
ANGLE OF MANDIBLE
SUBMANDIBULAR GLAND
UVULA
PALATINE TONSIL
ROOT OF TONGUE
PALATOPHARYNGEAL FOLD
PROMINENCE CAUSED BY GREATER CORNU OF HYOID BONE
EPIGLOTTIS
ADITUS OF LARYNX
PROMINENCE CAUSED BY SUPERIOR HORN OF THYROID CARTILAGE
ARYEPIGLOTTIC FOLD
CUNEIFORM TUBERCLE
PIRIFORM RECESS
CORNICULATE TUBERCLE
FOLD OVER SUPERIOR LARYNGEAL NERVE
INTERARYTENOID INCISURE
PROMINENCE OVER CRICOID CARTILAGE
NASAL PHARYNX
ORAL PHARYNX
LARYNGEAL PHARYNX (HYPOPHARYNX)
ESOPHAGUS
TRACHEA
F. Netter M.D.
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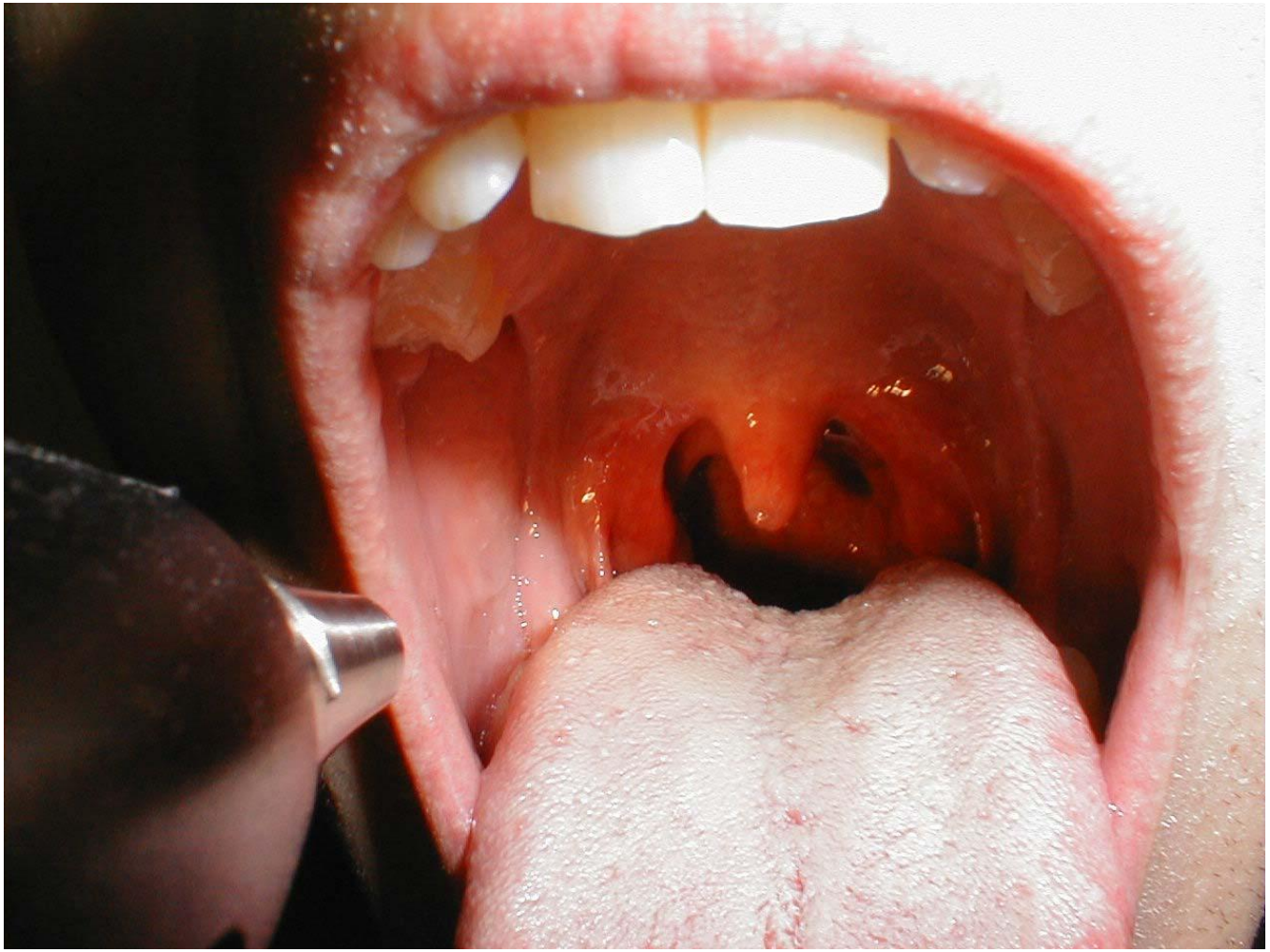
Pharyngitis



Beefy redness of posterior pharynx, which is the result of infection.

Palate Edema Due To Pharyngitis

Larynx (Voicebox)

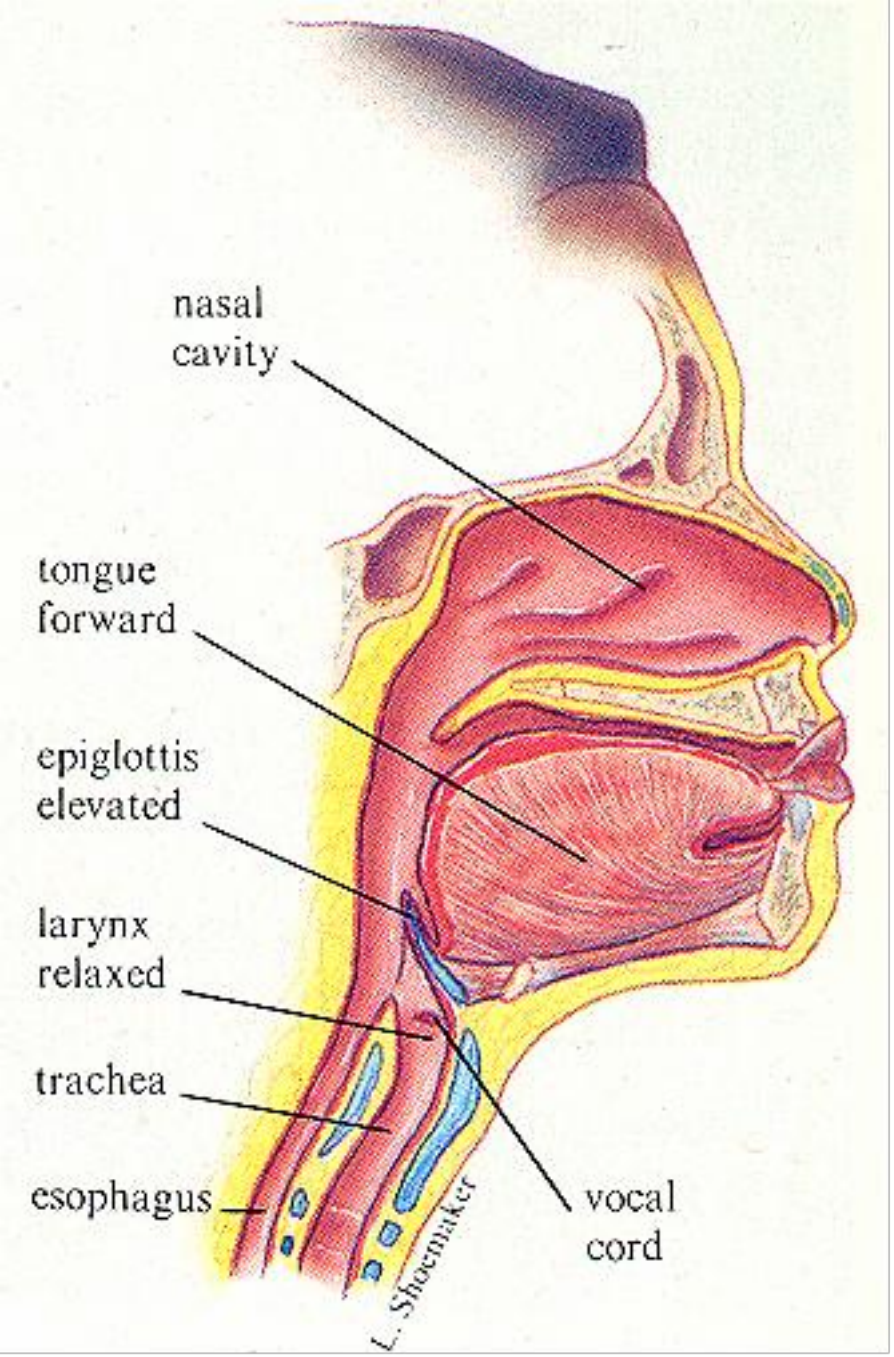
- A short passageway that connects the pharynx with the trachea.

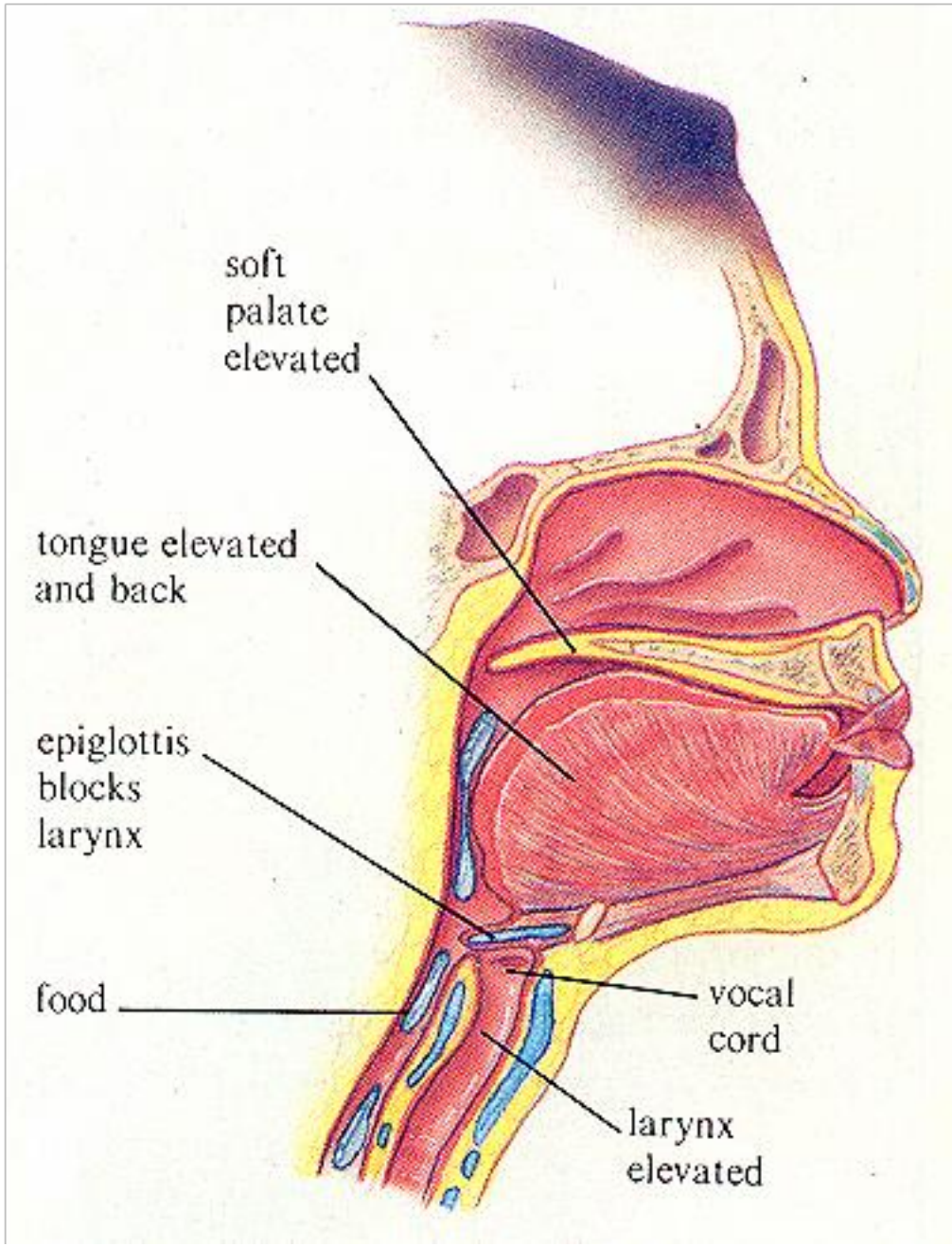
Anatomy

- The walls are composed of nine pieces of cartilage
  - three single
    - thyroid, epiglottis, and cricoid cartilage
  - Three paired (1 pair is the most important)
    - arytenoid cartilage

Laryngeal Cartilages

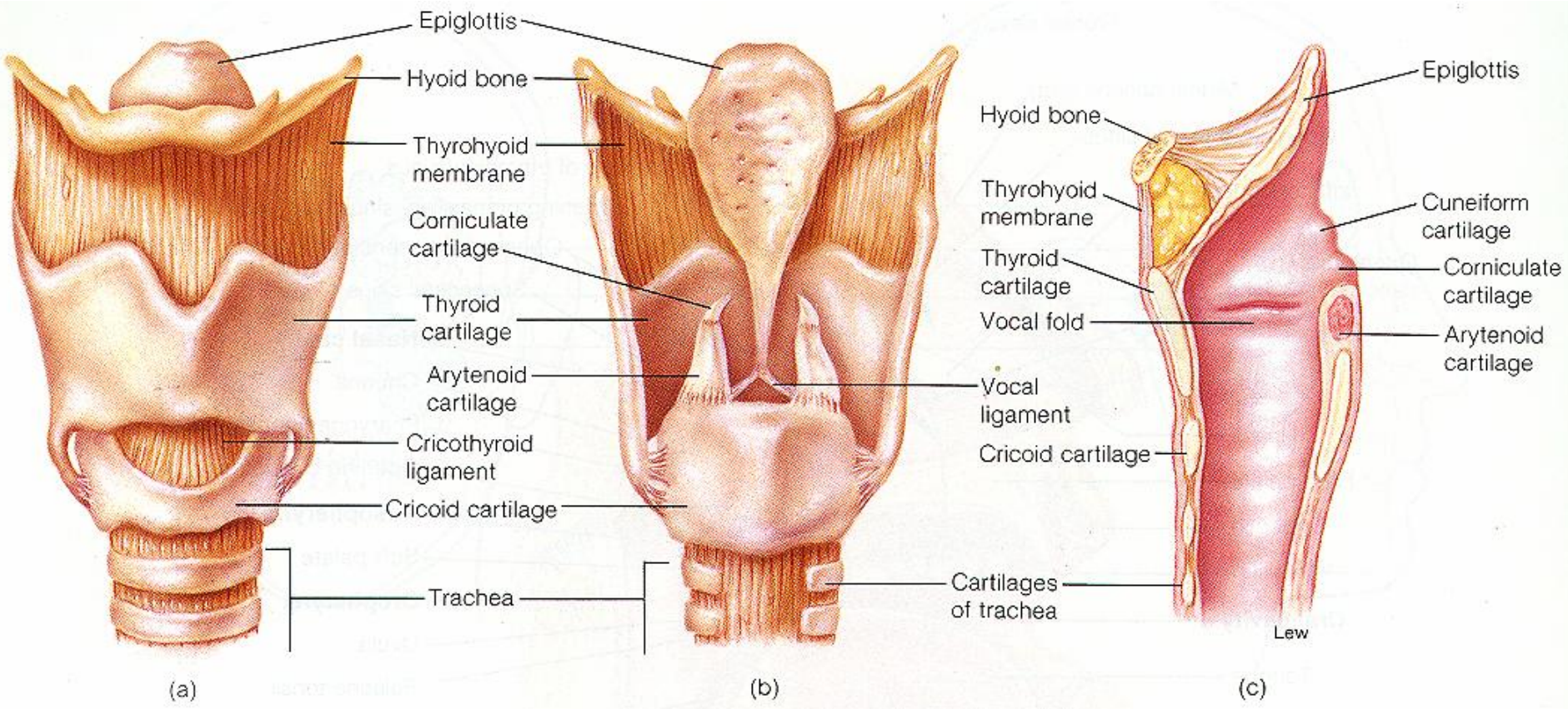
- Thyroid cartilage (Adam's apple)
  - consist of hyaline catilage and forms the front of the larynx and gives it its triangular shape.
- Epiglottis
  - large leaf shaped piece of elastic cartilage covered by epithelium lying over the top of the larnyx.
  - During swallowing, the epiglottis covers the glottis (the passageway leading to the true and false vocal cords) so that food does not enter the lungs, thereby routing it to the esophagus.


nasal cavity
tongue forward
epiglottis elevated
larynx relaxed
trachea
esophagus
vocal cord
L. Shoemaker

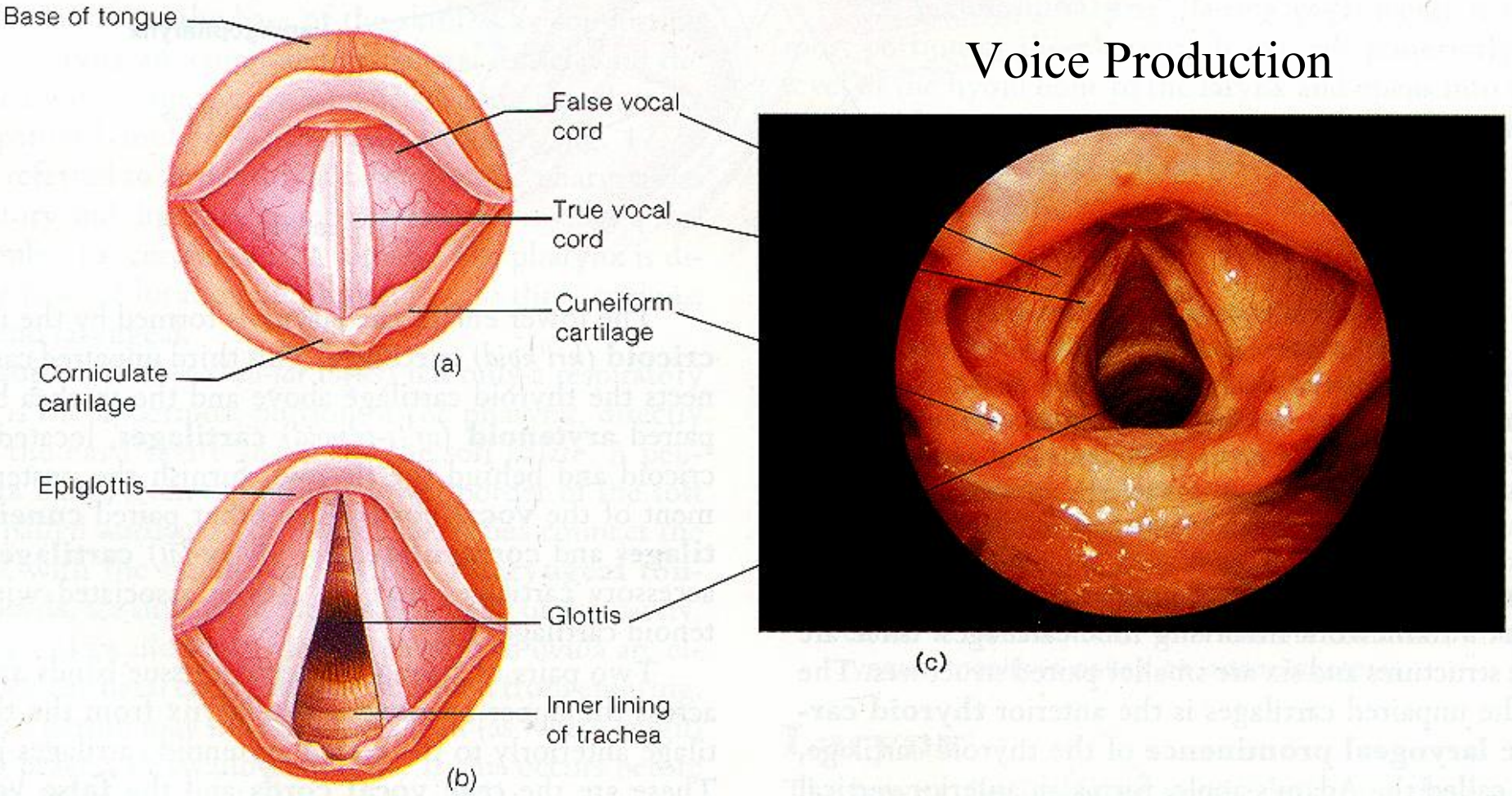

soft palate elevated
tongue elevated and back
epiglottis blocks larynx
food
vocal cord
larynx elevated

Laryngeal Cartilages (cont)

- Cricoid cartilage
  - is a ring of hyaline cartilage attached to the first ring of cartilage of the trachea.
- Arytenoid cartilage
  - mostly hyaline cartilage located above the cricoid cartilage
  - attach the true vocal cords and pharyngeal muscles and function in voice production.


Epiglottis
Hyoid bone
Thyrohyoid membrane
Corniculate cartilage
Thyroid cartilage
Arytenoid cartilage
Cricothyroid ligament
Cricoid cartilage
Trachea
Epiglottis
Vocal ligament
Cartilages of trachea
Hyoid bone
Thyrohyoid membrane
Thyroid cartilage
Vocal fold
Cricoid cartilage
Epiglottis
Cuneiform cartilage
Corniculate cartilage
Arytenoid cartilage
Lew
(a)
(b)
(c)

Voice Production



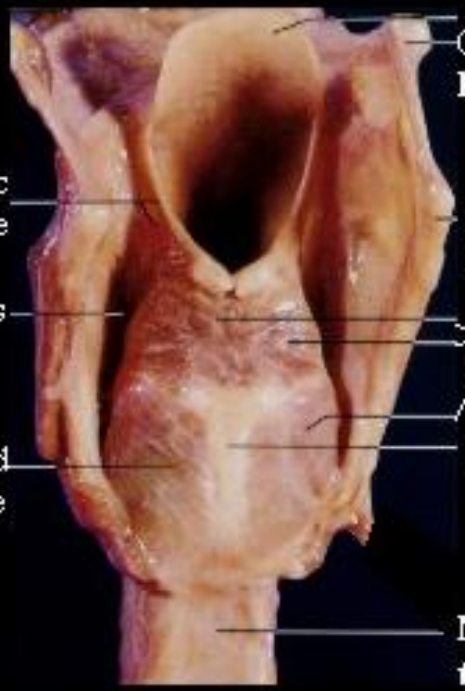
False vocal cords- function to hold the breath against pressure in the thorax such as might occur when straining to lift a heavy object.

True vocal cords- produce sound. They contain elastic ligaments stretched between pieces of rigid cartilage via muscle. The muscle tightens and relaxes the cord causing tension variations.

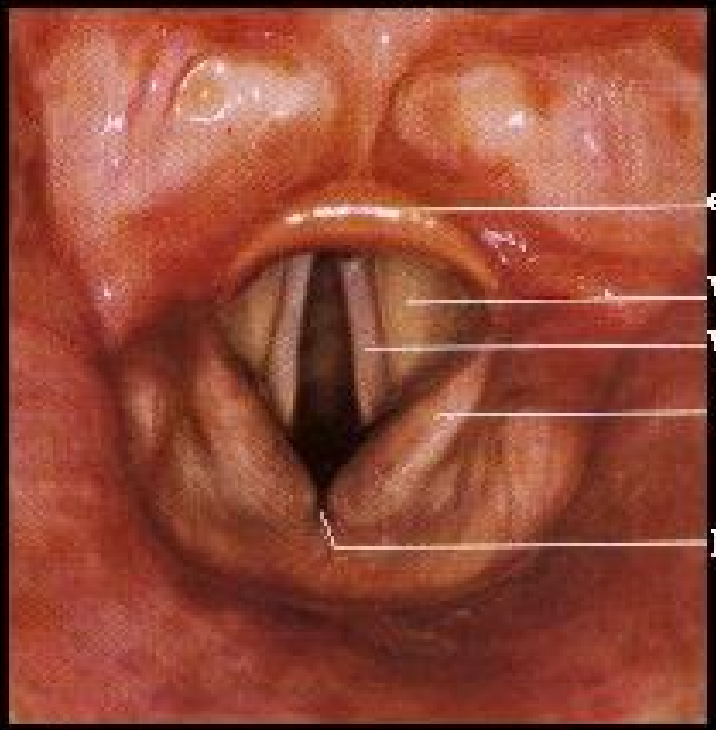
Laryngitis- inflammation of the larynx causing swelling of the cords and a henderance to vibration (hoarseness).

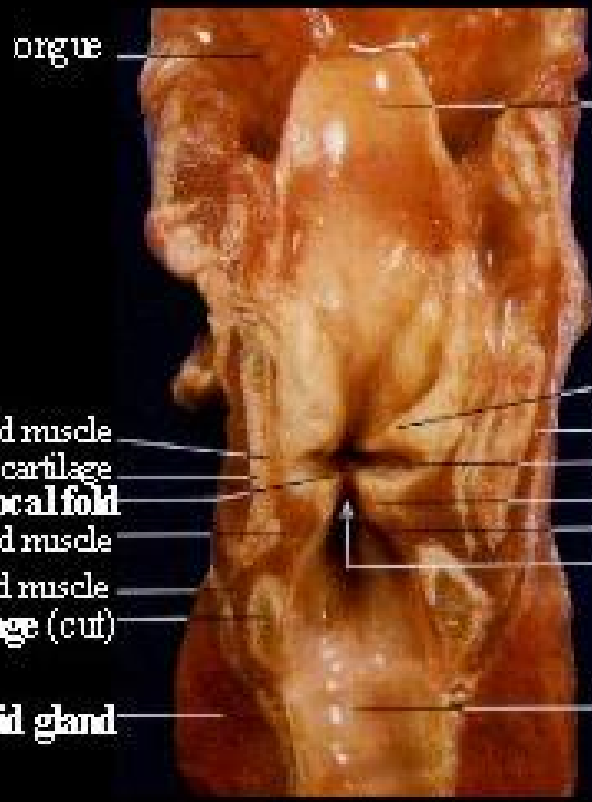
Larynx, anterior view

Larynx, posterior view



Glottis, superior view





Trachea

- Extends form the larynx to the upper part of the fifth vertebra, where it divides into right and left primary bronchi.
- The wall is lined by pseudostratified ciliated columnar epithelium with goblet and basal cells.
- Walls have “C” shaped cartilagenous rings that provides rigid support to prevent collapse.
- Tracheostomy- emergency airway through the trachea
- Intubation- the insertion of a tube through the mouth or nose down through the larnyx and treachea.

Redesigning the intubation tube

An intubation tube is a flexible tube placed directly into the trachea, or windpipe, for patients requiring assisted breathing or lung protection. It is commonly used during general anesthesia and may be used to keep the airway open or when a person cannot breathe properly.

Standard intubation tube

Top portion sticks out of mouth and attaches to balloon bag

Air injection bladder to inflate cuff

Flexible main tube

Air injection tube

Circumferential cuff inflates to keep tube in place against the walls of the trachea

Bottom portion inserted into throat

Variation 1 *as patented by Dr. Jim Simon and son*

Sleeve within tube contains malleable metal wire to help tube conform to shape of trachea and keep tube in place

Sleeve can be lit by fiber optics or chemical used in Halloween glow sticks

Variation 2

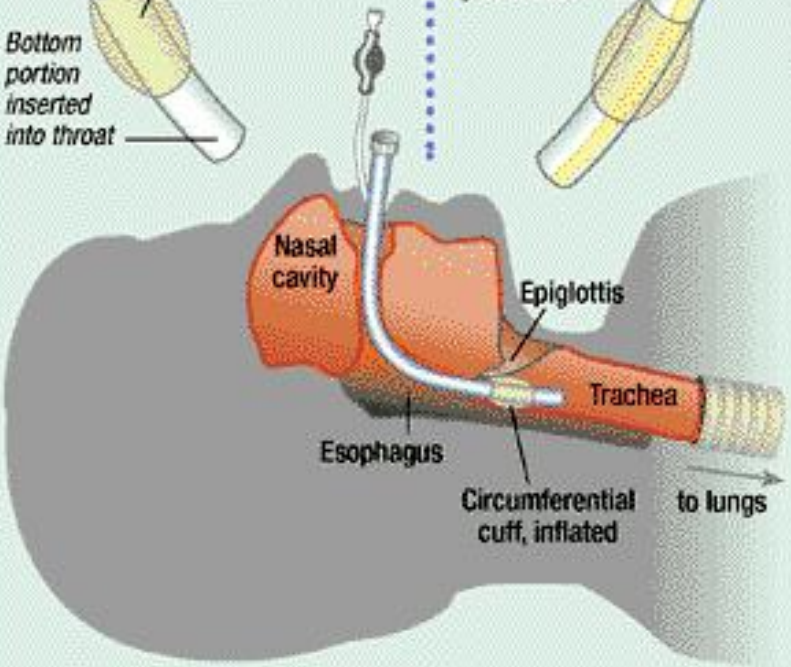
Fiber-optic cable to channel electrical or chemical light through tube

Balloon bag attachment

Flexible tubing to suction source

Wire and suction connection is built into the tube wall interior

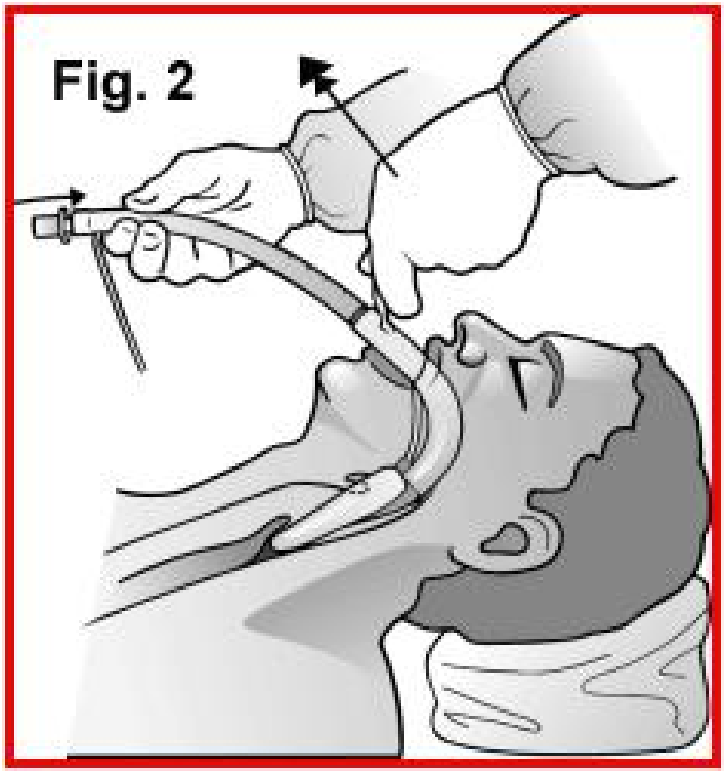
Optional chemical light ring



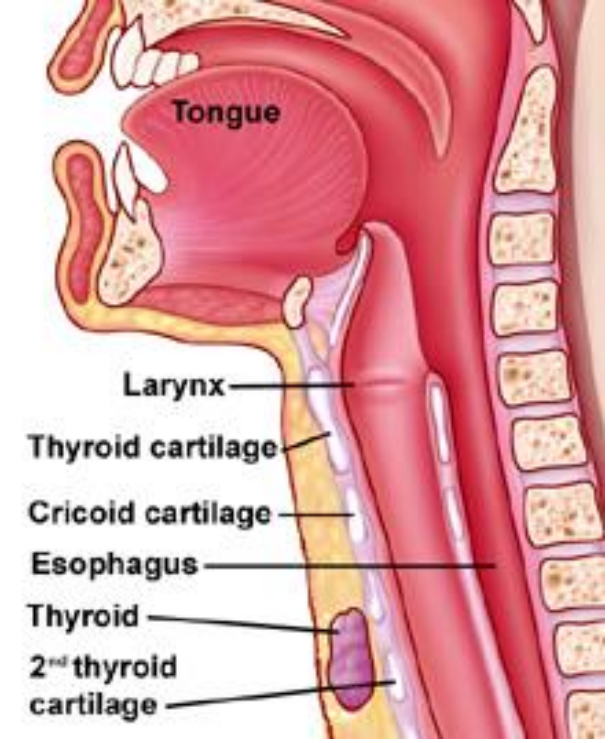
Once the tube has been inserted through the mouth (or nose) it is attached to a bag that can be squeezed to deliver breaths to the lungs. The placement of a tube essentially ensures a closed system that connects directly to the lungs.

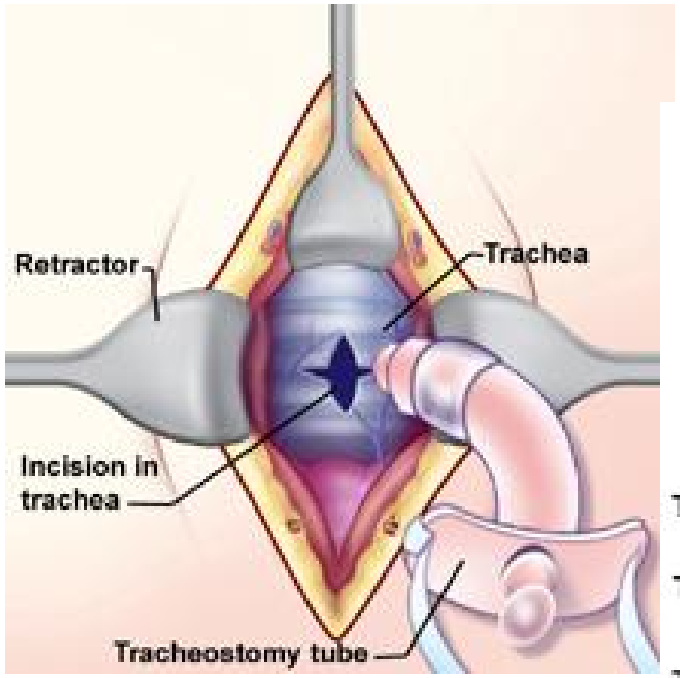
Source: Capitol Anesthesiology Association, Texas web site: www.healthanswers.com

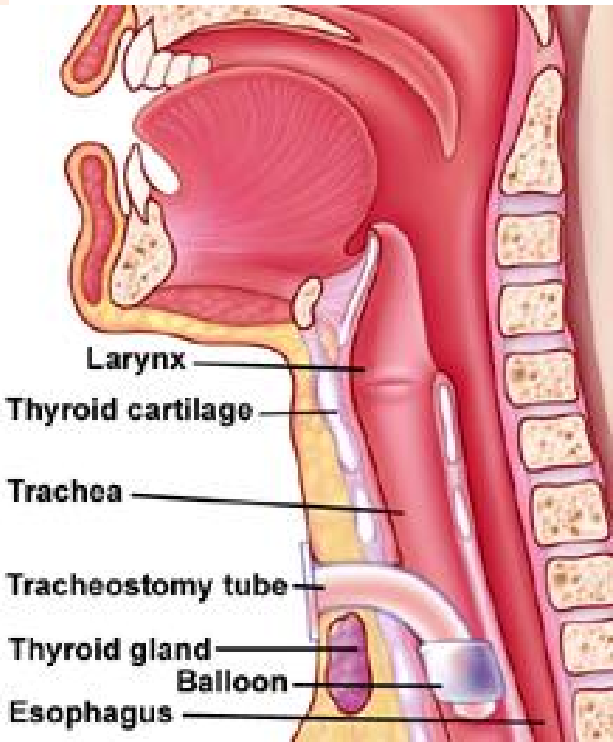
IJ graphic/Steve Greenberg

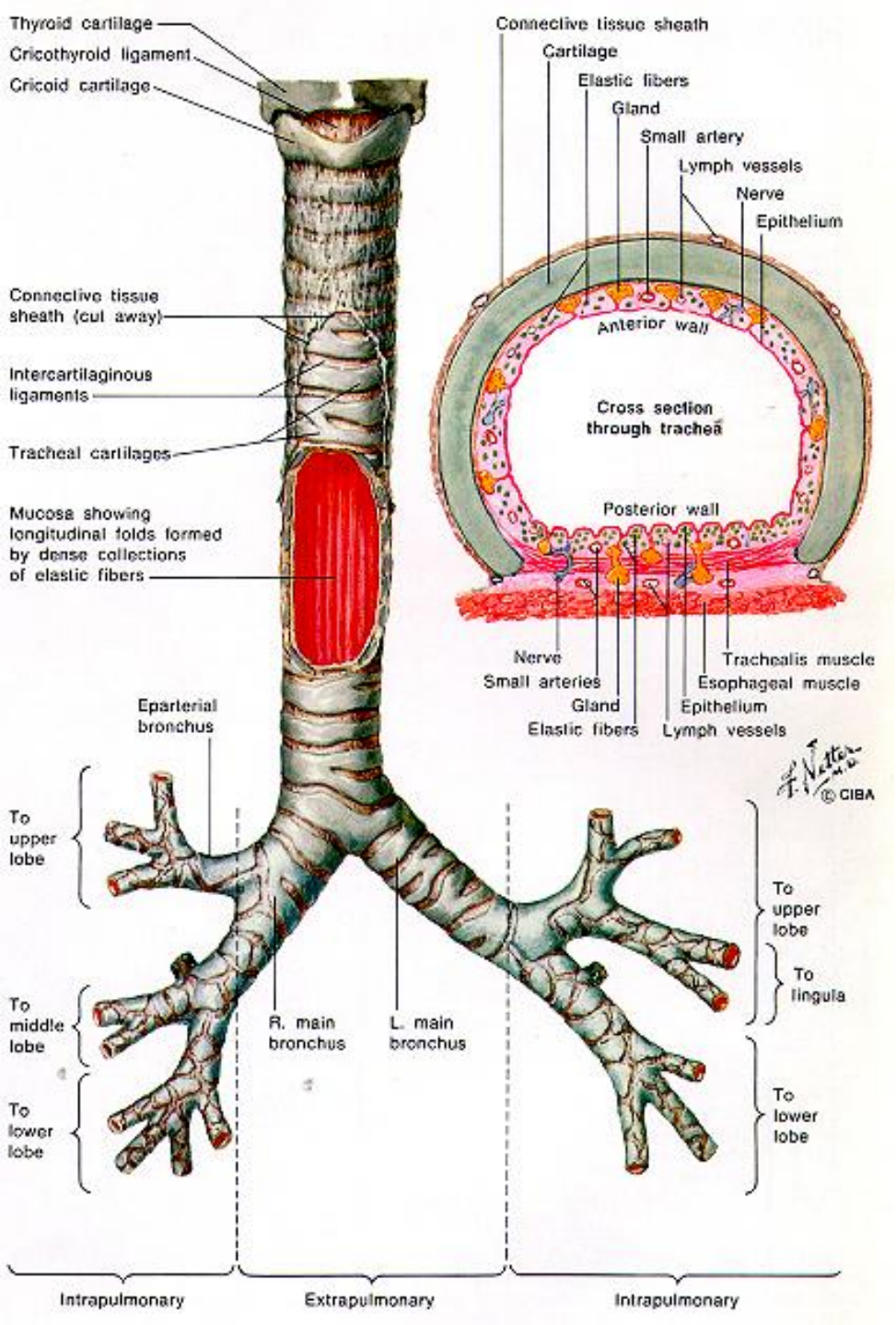


Tracheostomy



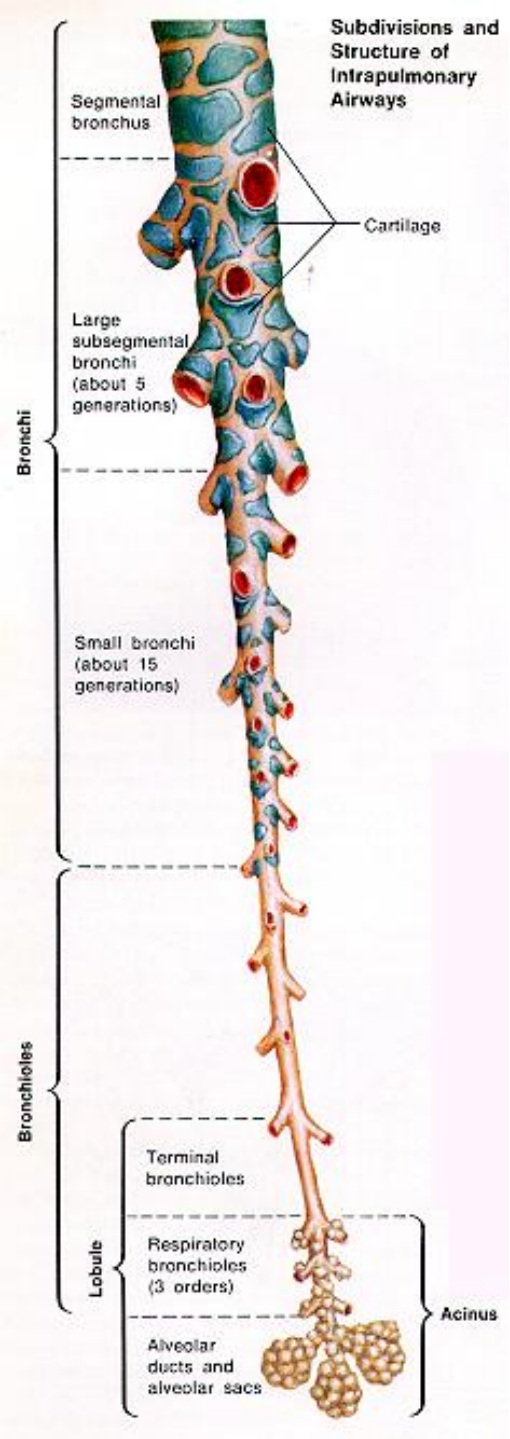






Bronchial Tree

- Trachea
- Primary Bronchi- right more straight, object caught here.
- Secondary Bronchi
- Tertiary Bronchi
- Bronchioles
- Terminal Bronchioles



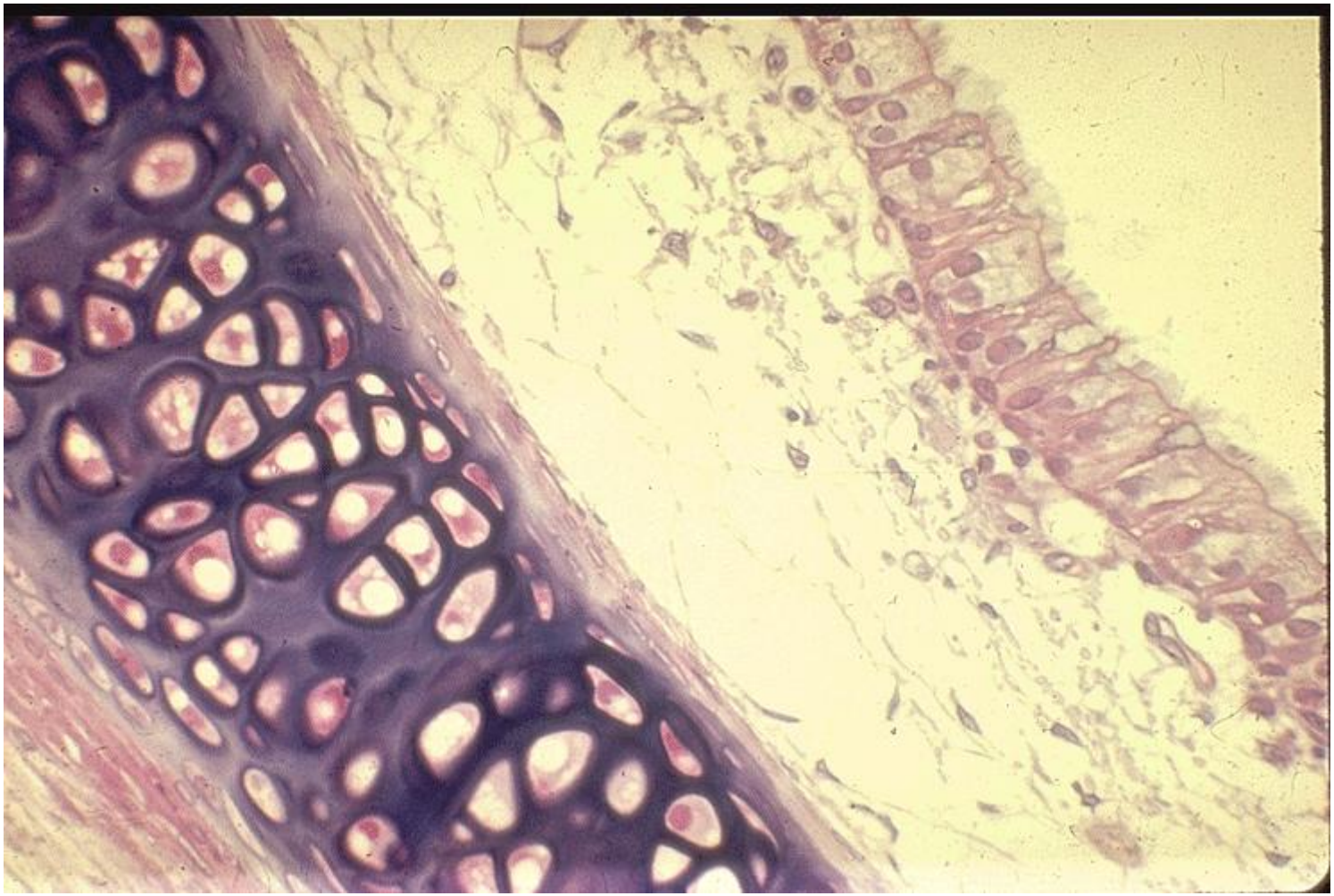
Structural Changes of Bronchioles

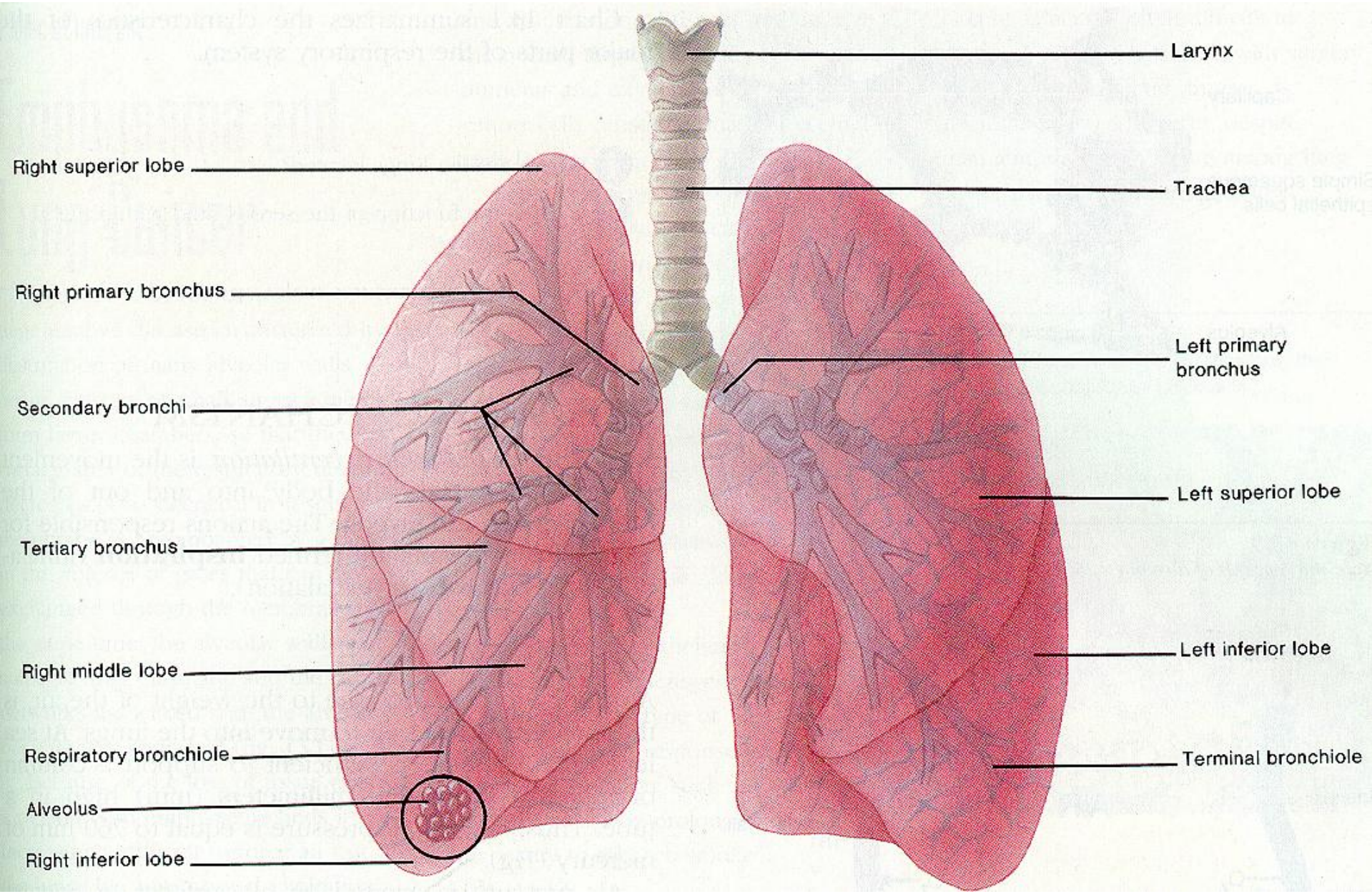
- no cartilage at bronchioles
- increase of smooth muscle at bronchioles
- epithelium changes to cuboidal non-ciliated and then to simple squamous in terminal bronchioles.

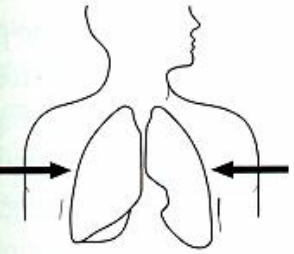
- Muscular contraction controlled by the autonomic nervous system and various chemical (inhaled irritants and chemicals from inflammatory cells)
- **Asthma**- smooth muscle spasm that closes off the bronchioles
- **Bronchoscopy**- the visual examination of the bronchi through a **bronchoscope**.

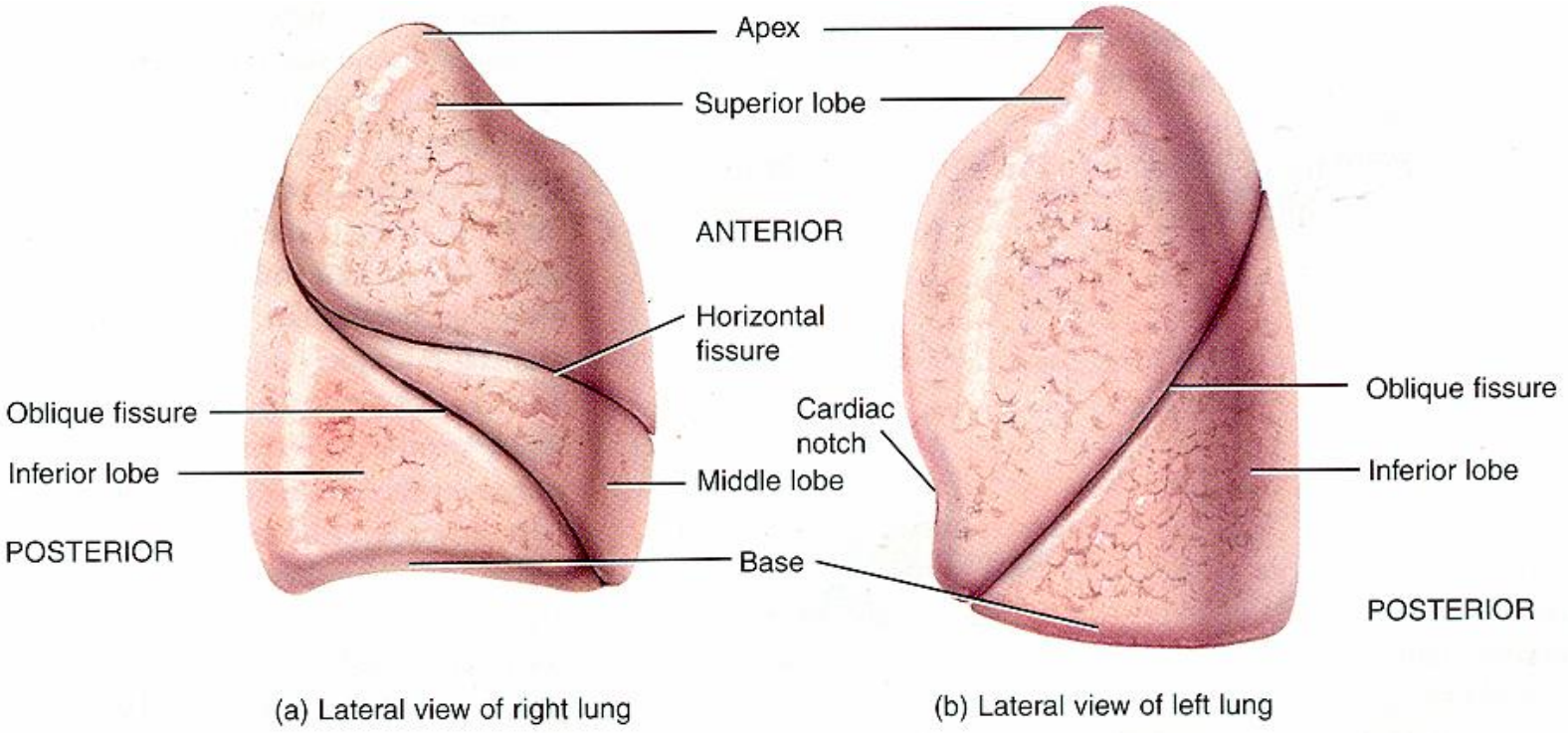
Cilliated
ColumnarEpithelium

Cartilage ring



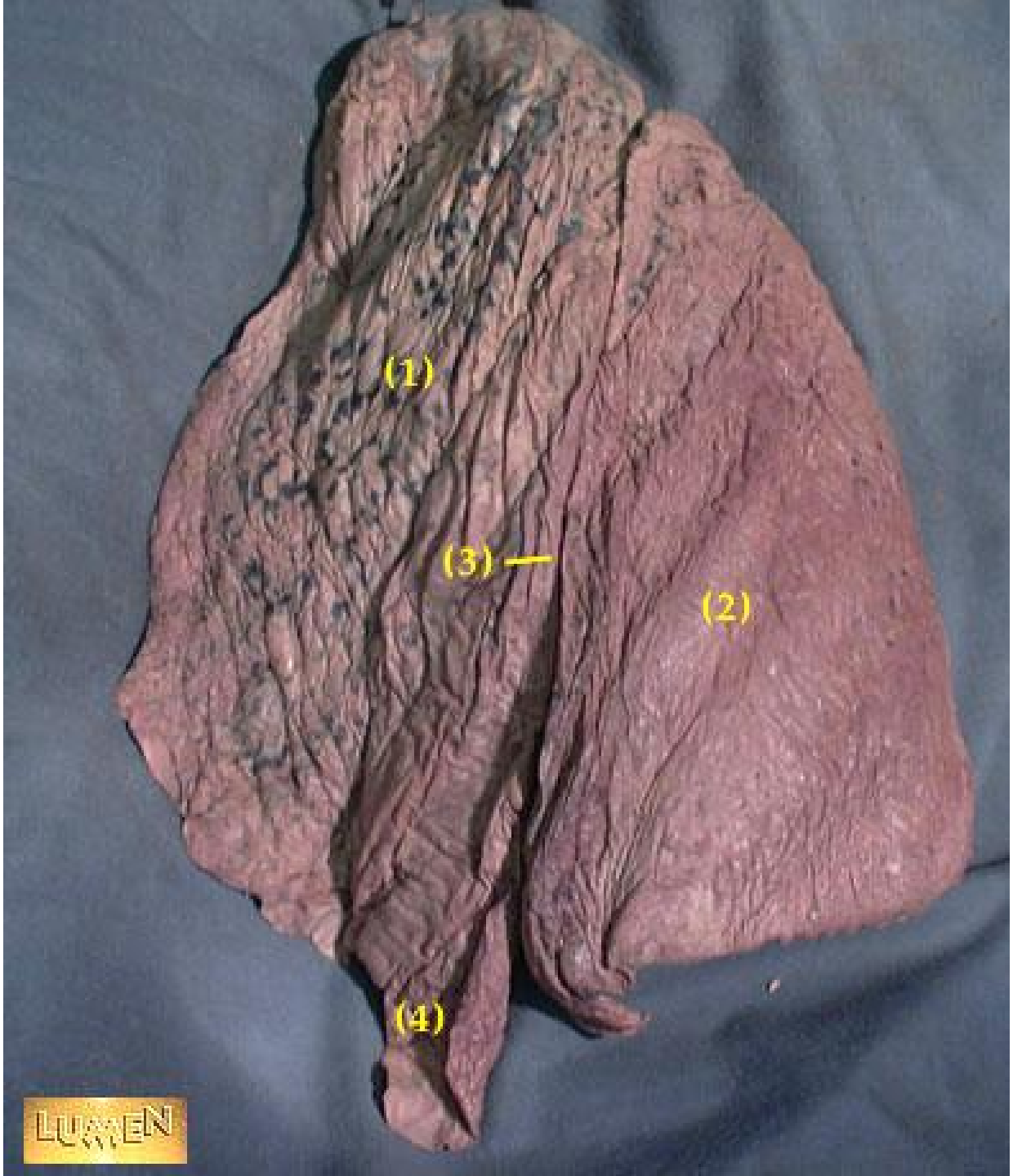

Larynx
Right superior lobe
Trachea
Right primary bronchus
Left primary bronchus
Secondary bronchi
Left superior lobe
Tertiary bronchus
Left inferior lobe
Right middle lobe
Respiratory bronchiole
Terminal bronchiole
Alveolus
Right inferior lobe



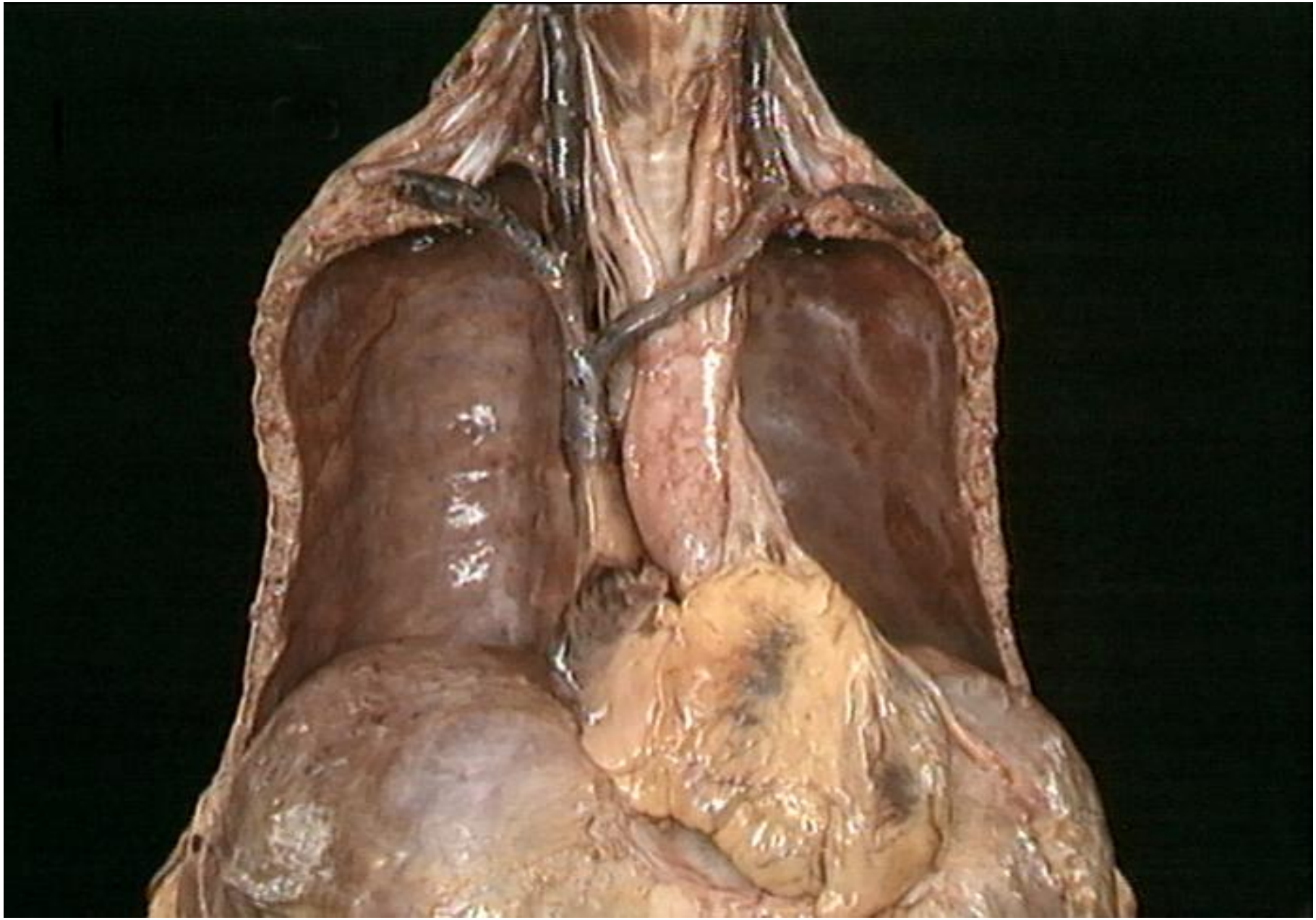


(a) Lateral view of right lung

(b) Lateral view of left lung


(1)
(3)
(2)
(4)

The smooth, glistening pleural surface of a lung is shown here. This patient had marked pulmonary edema, which increased the fluid in the lymphatics that run between lung lobules. Thus, the lung lobules are outlined in white.



BRANCHING OF BRONCHIAL TREE

Trachea

↓

Primary bronchi

↓ To each lung

Secondary bronchi

↓ To each lung lobe

Tertiary bronchi

↓ Bronchopulmonary segment

Bronchioles

↓

Terminal bronchioles

↓ To each lobule

Respiratory bronchioles

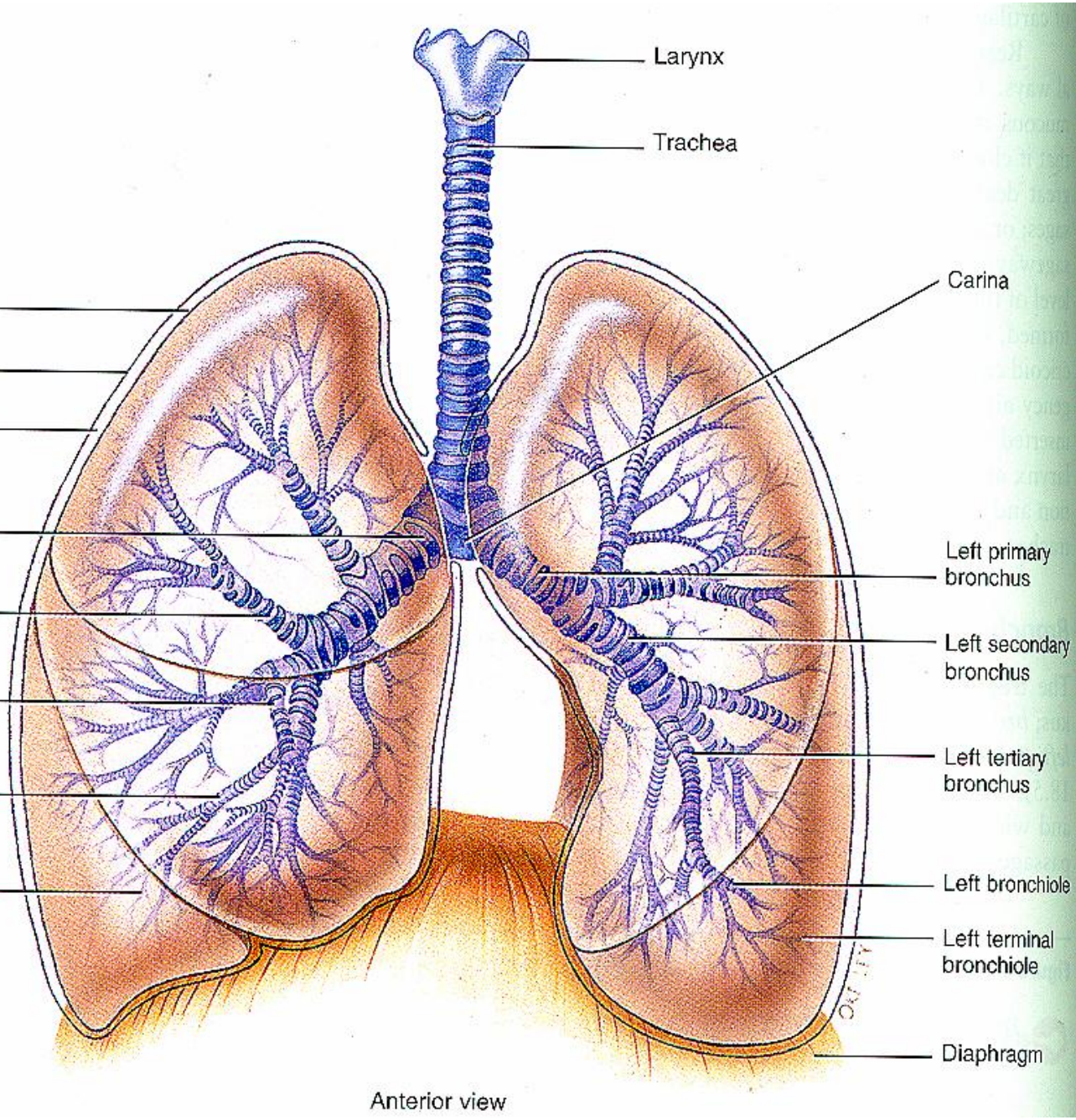
↓

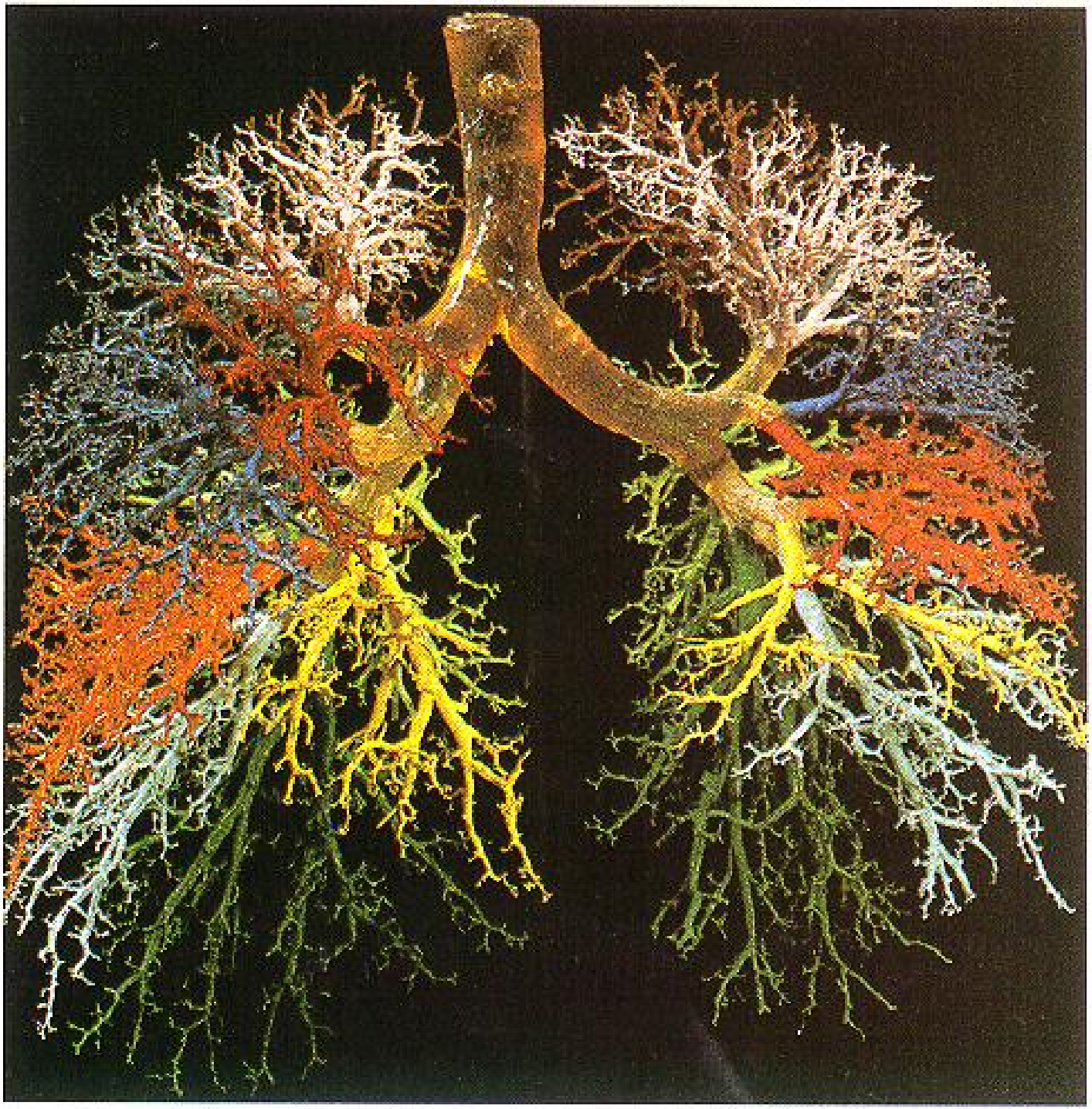
Alvolar ducts

↓

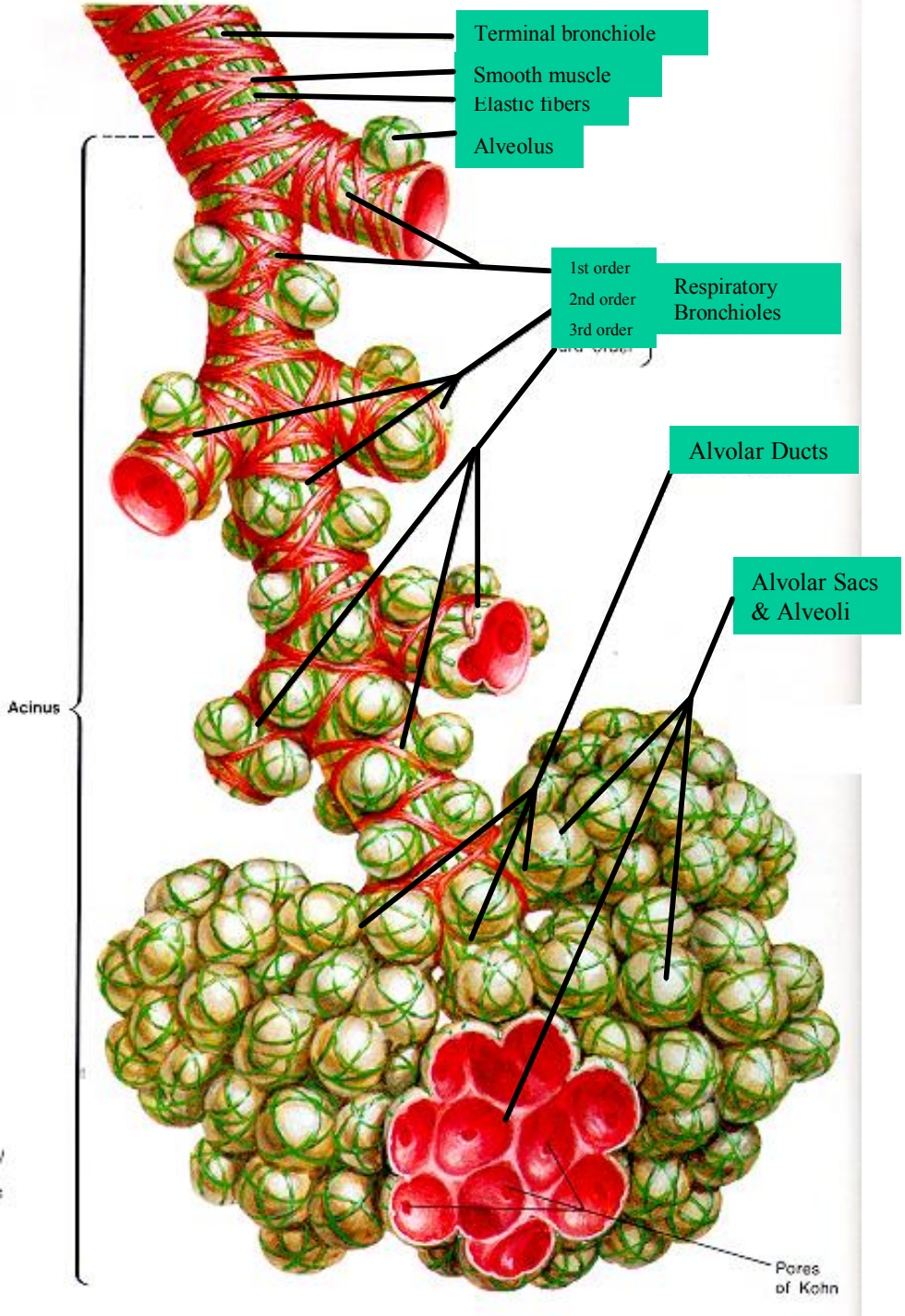
Alveolus- a epithelial lined sac where gas exchange occurs.

Alveolar sacs- two or more alveoli that share a common opening.

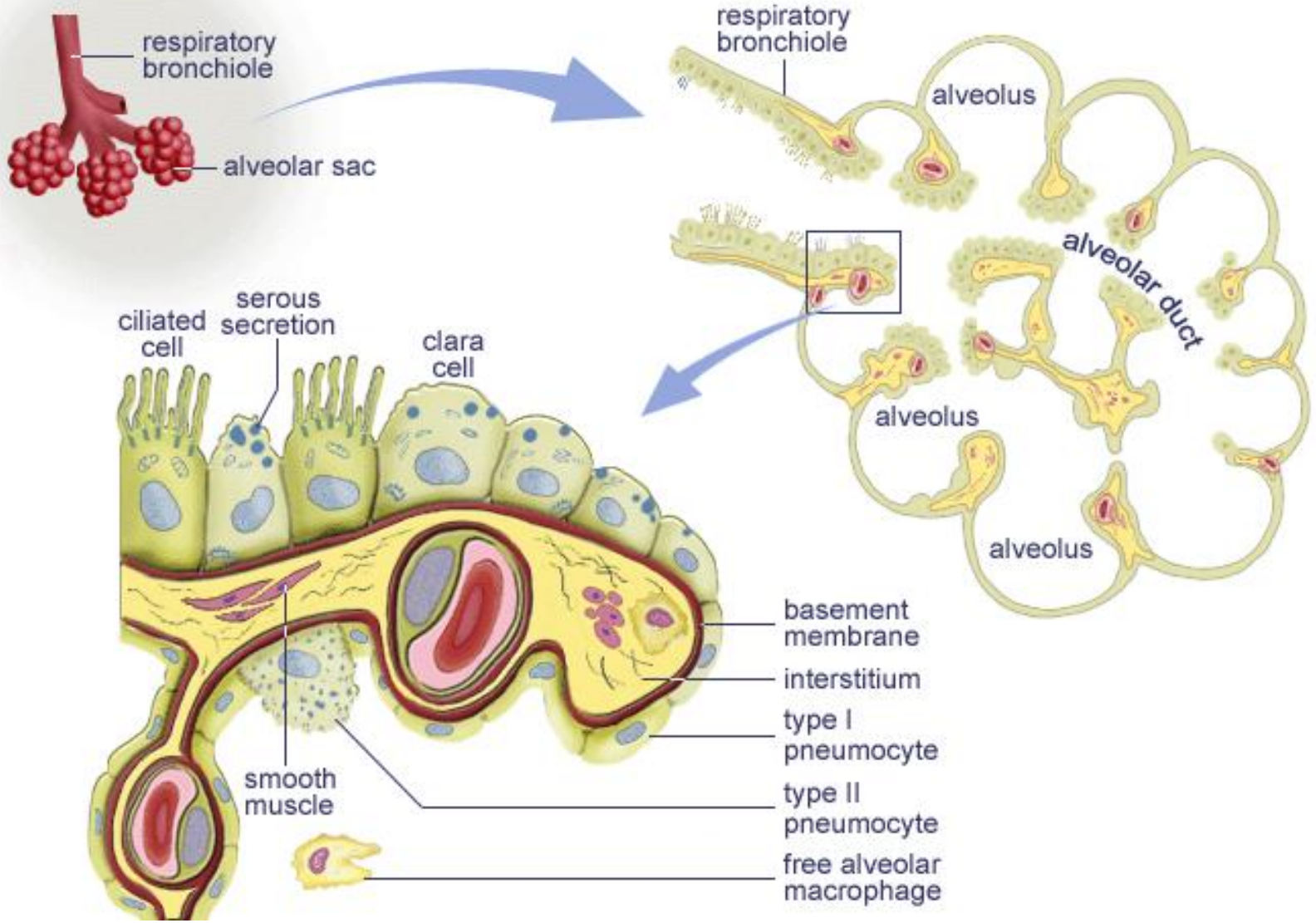


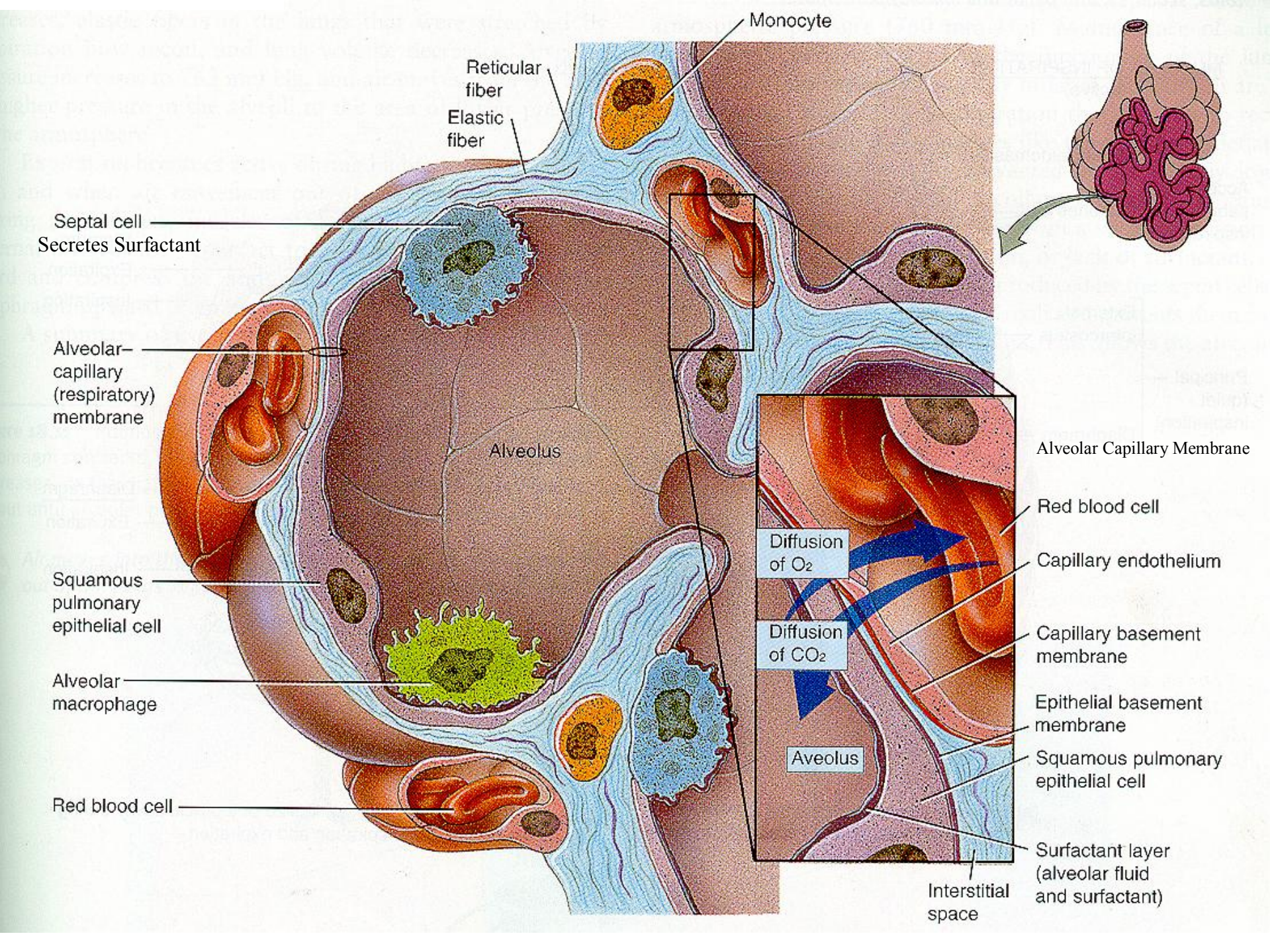


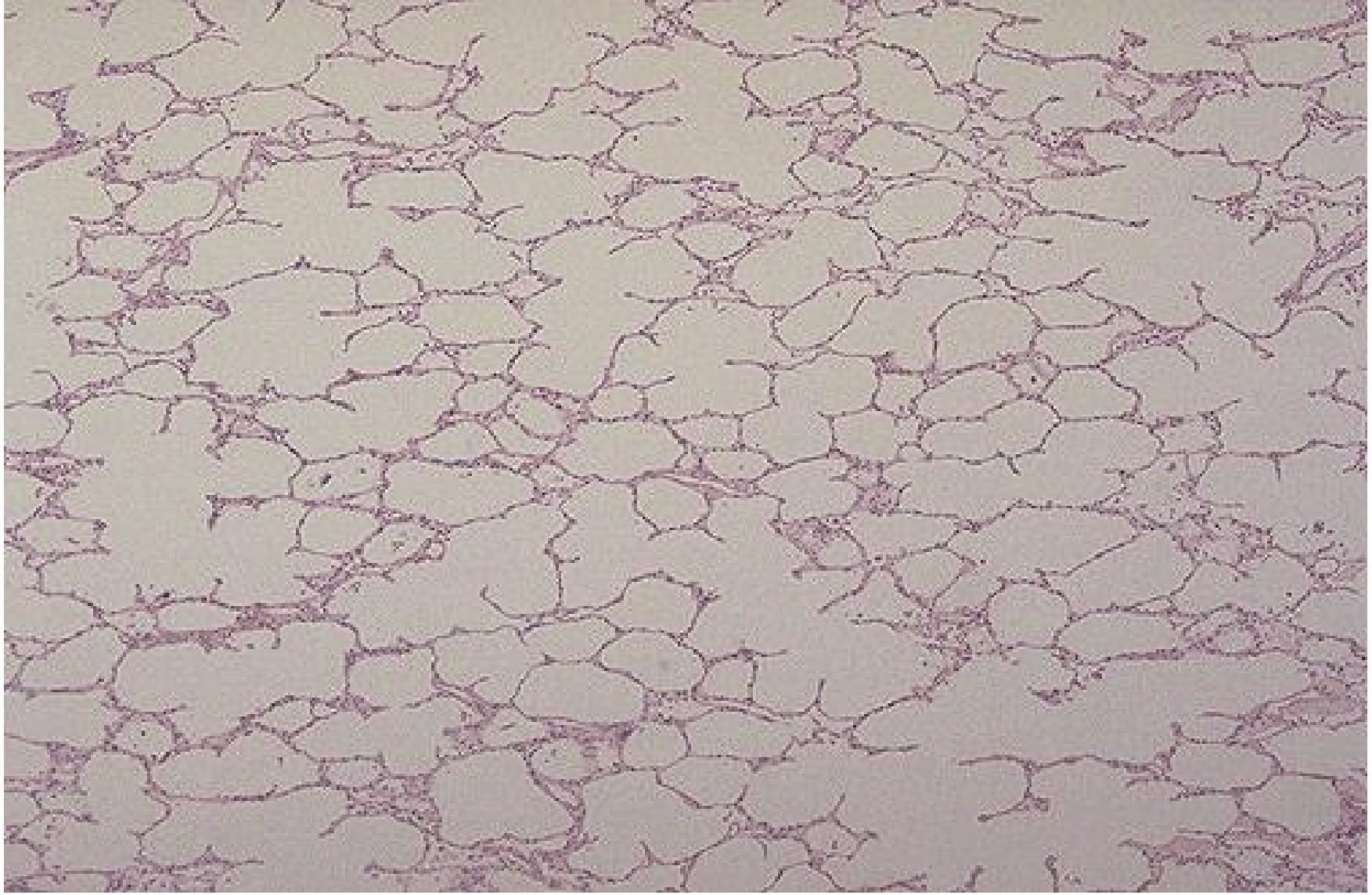
Lobule


Terminal bronchiole
Smooth muscle
Elastic fibers
Alveolus
1st order
2nd order
3rd order
Respiratory Bronchioles
Alvolar Ducts
Alvolar Sacs & Alveoli
Acinus
Pores of Kohn

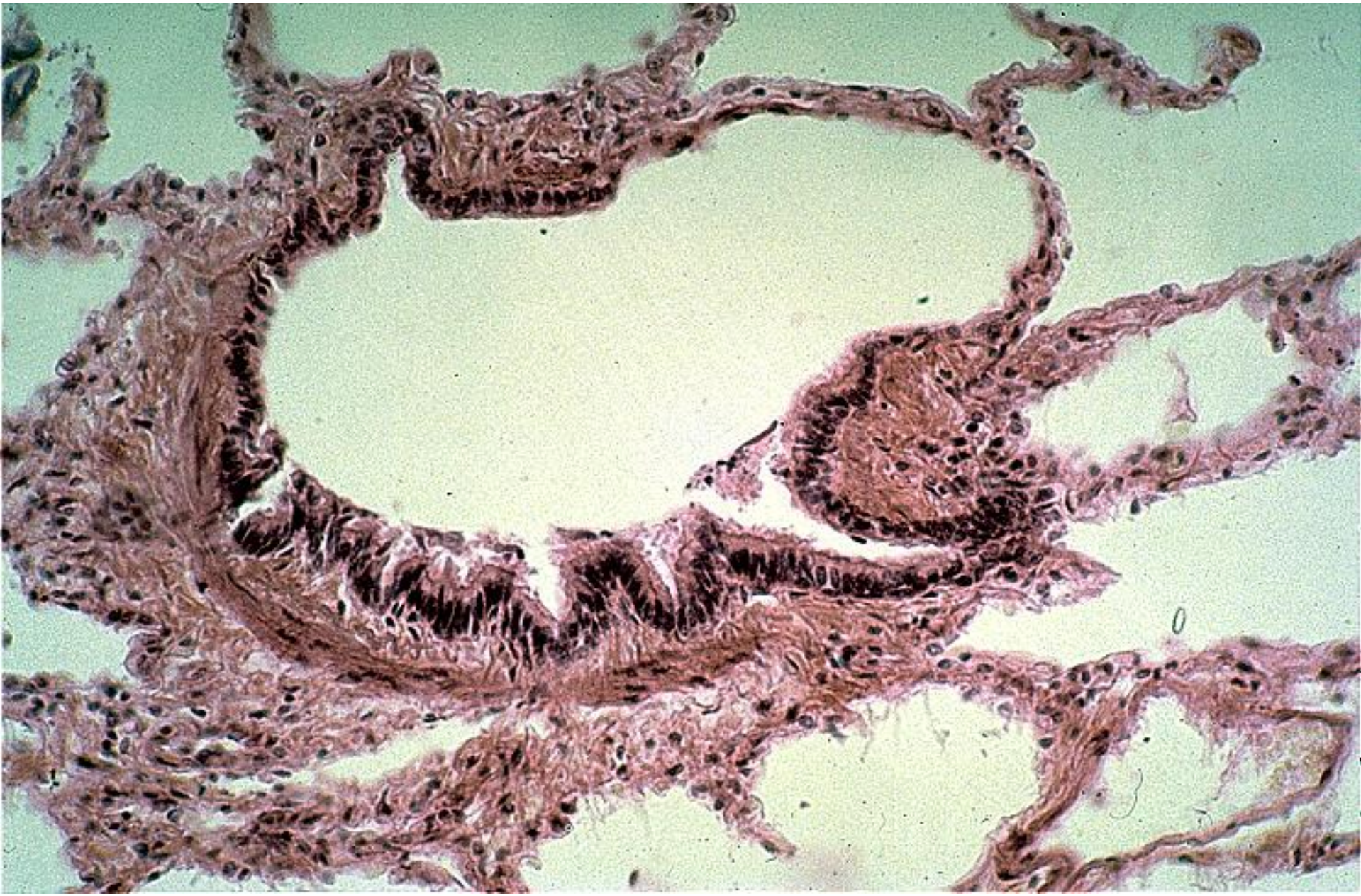
Respiratory Bronchiole



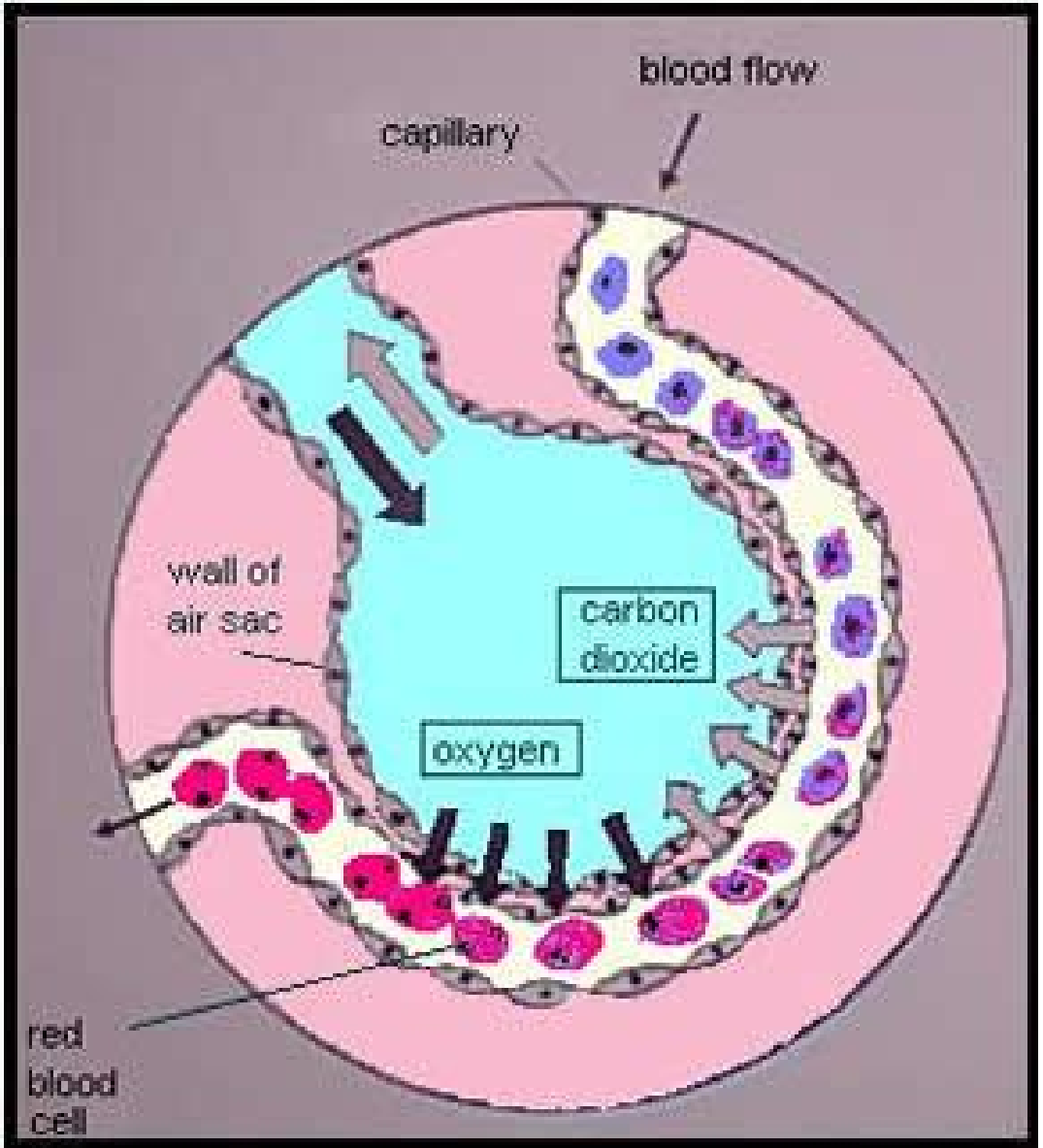

Monocyte
Reticular fiber
Elastic fiber
Septal cell
Secretes Surfactant
Alveolar–capillary (respiratory) membrane
Alveolus
Squamous pulmonary epithelial cell
Alveolar macrophage
Red blood cell
Alveolar Capillary Membrane
Red blood cell
Diffusion of O_2
Capillary endothelium
Diffusion of CO_2
Capillary basement membrane
Epithelial basement membrane
Aveolus
Squamous pulmonary epithelial cell
Surfactant layer (alveolar fluid and surfactant)
Interstitial space

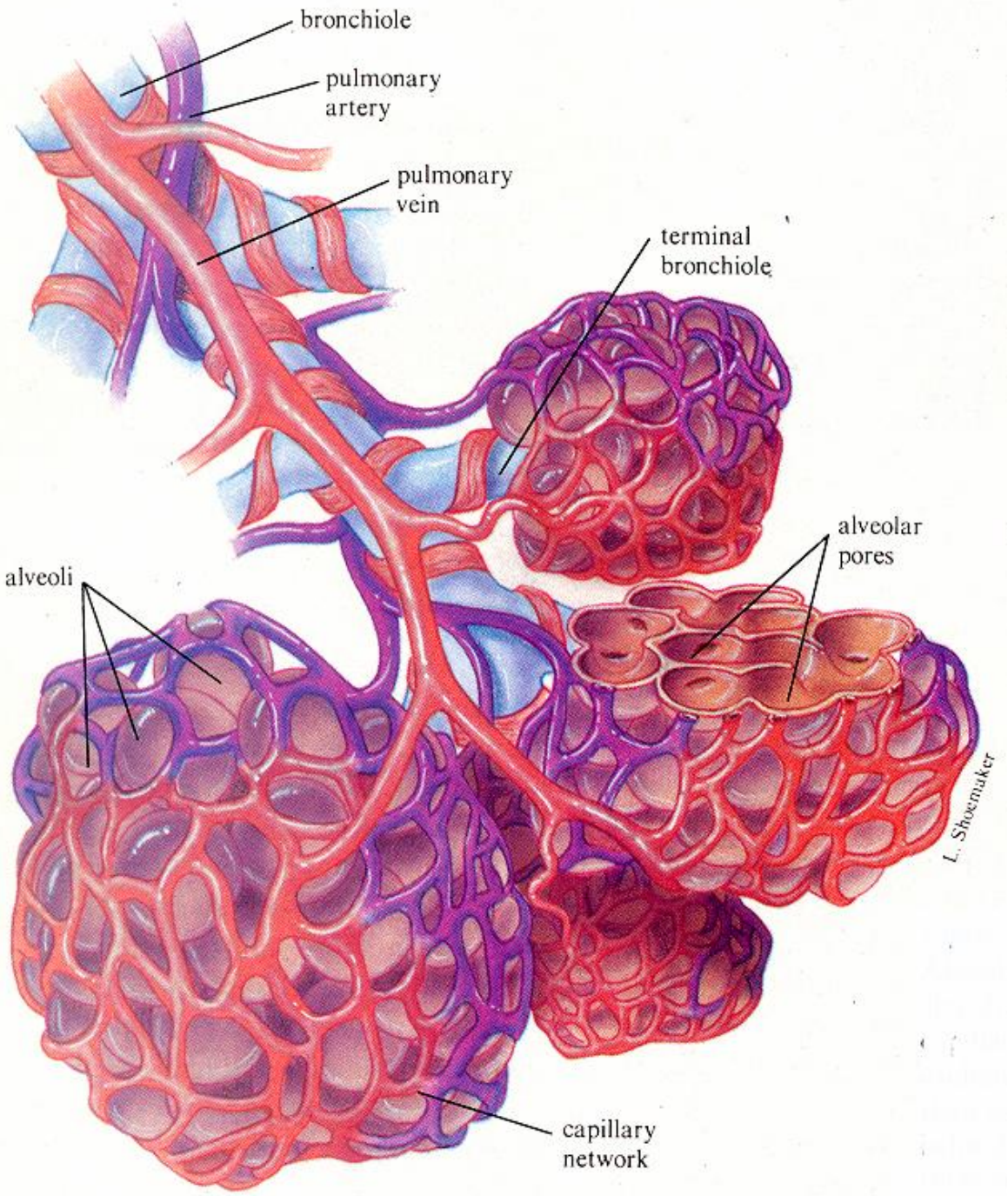


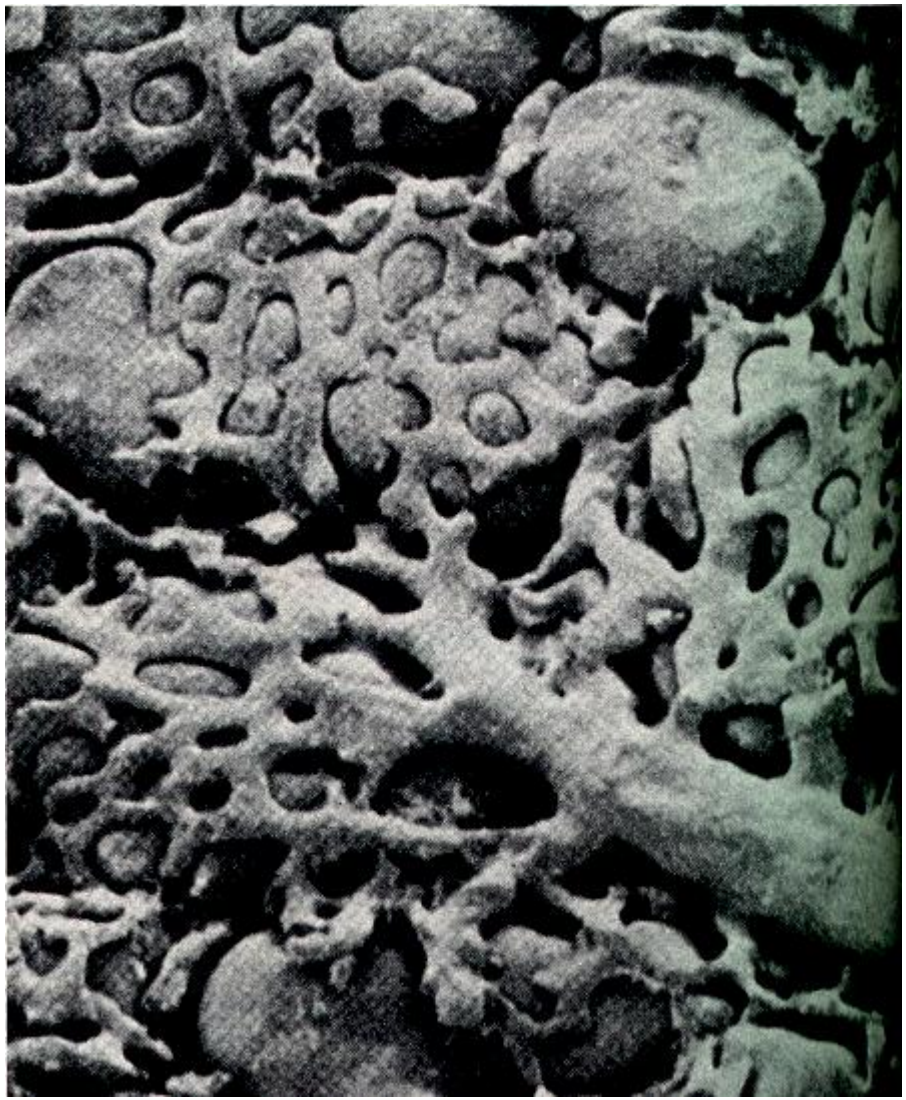
This is normal lung microscopically. The alveolar walls are thin and delicate. The alveoli are well-aerated and contain only an occasional pulmonary macrophage (type II pneumonocyte).

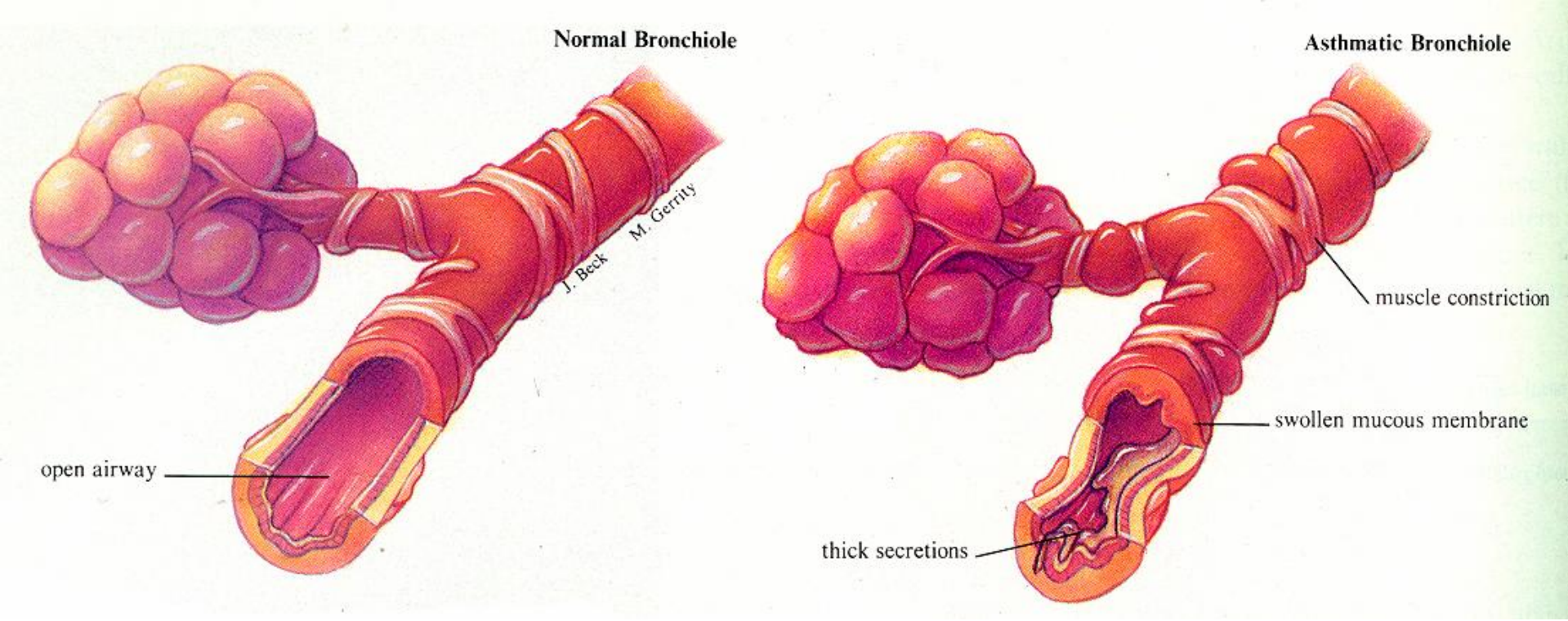


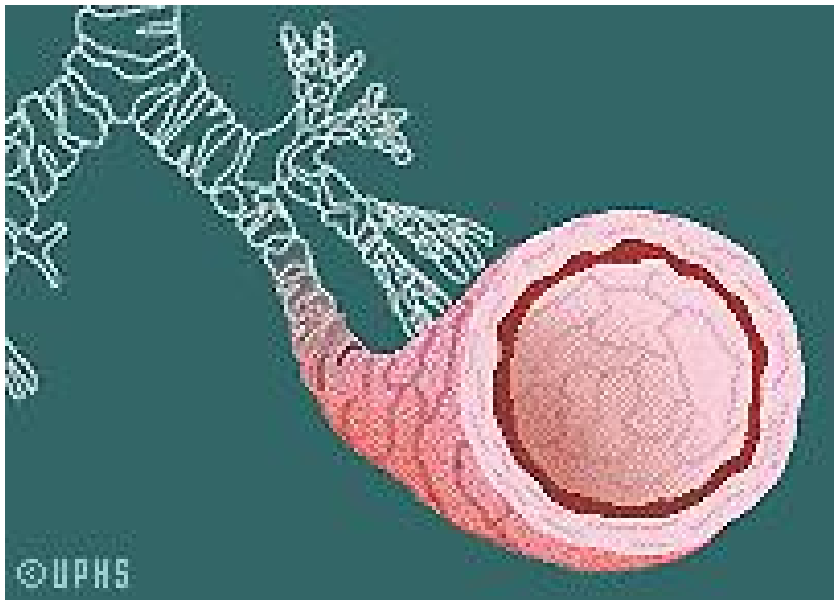
External Respiration

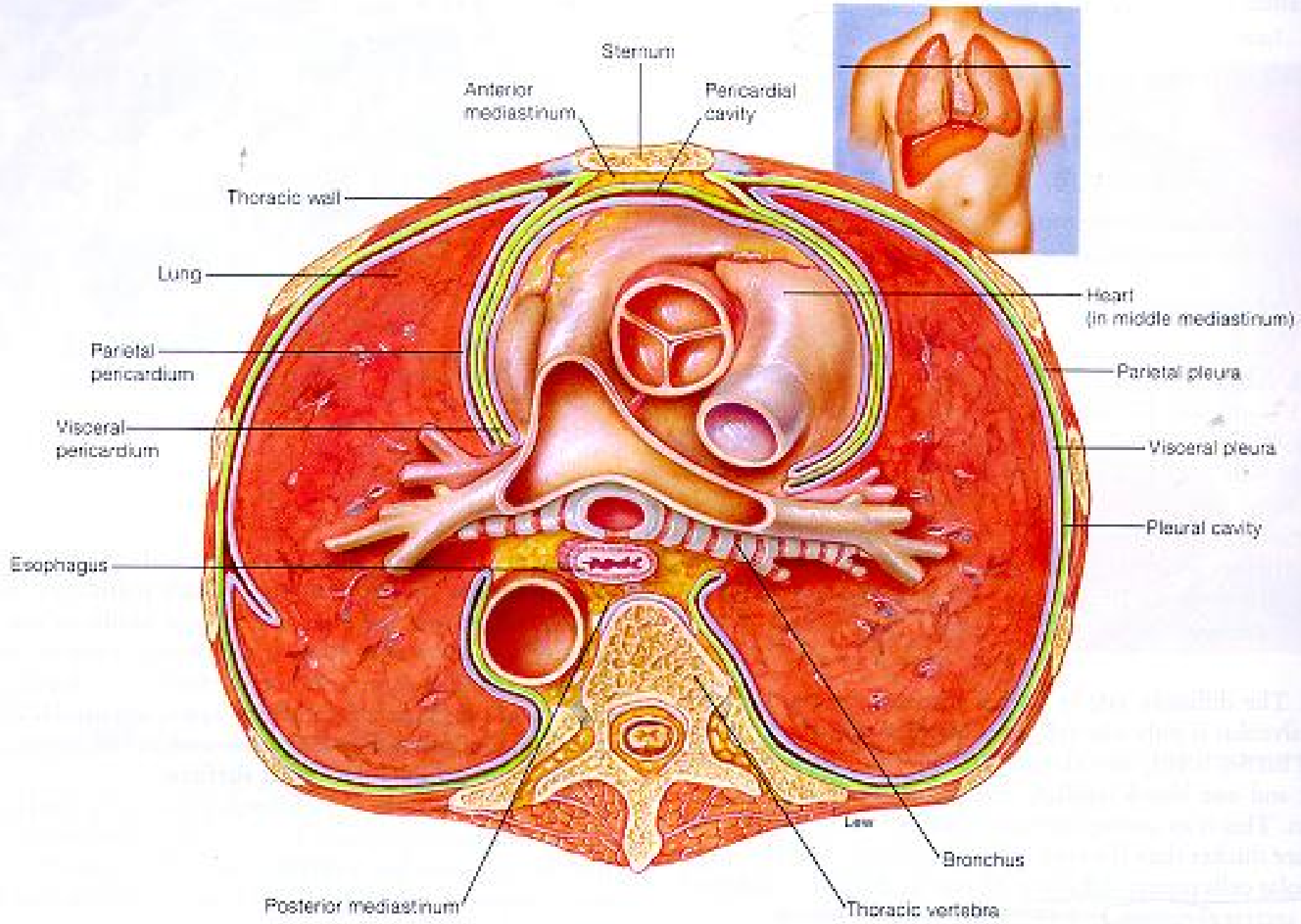


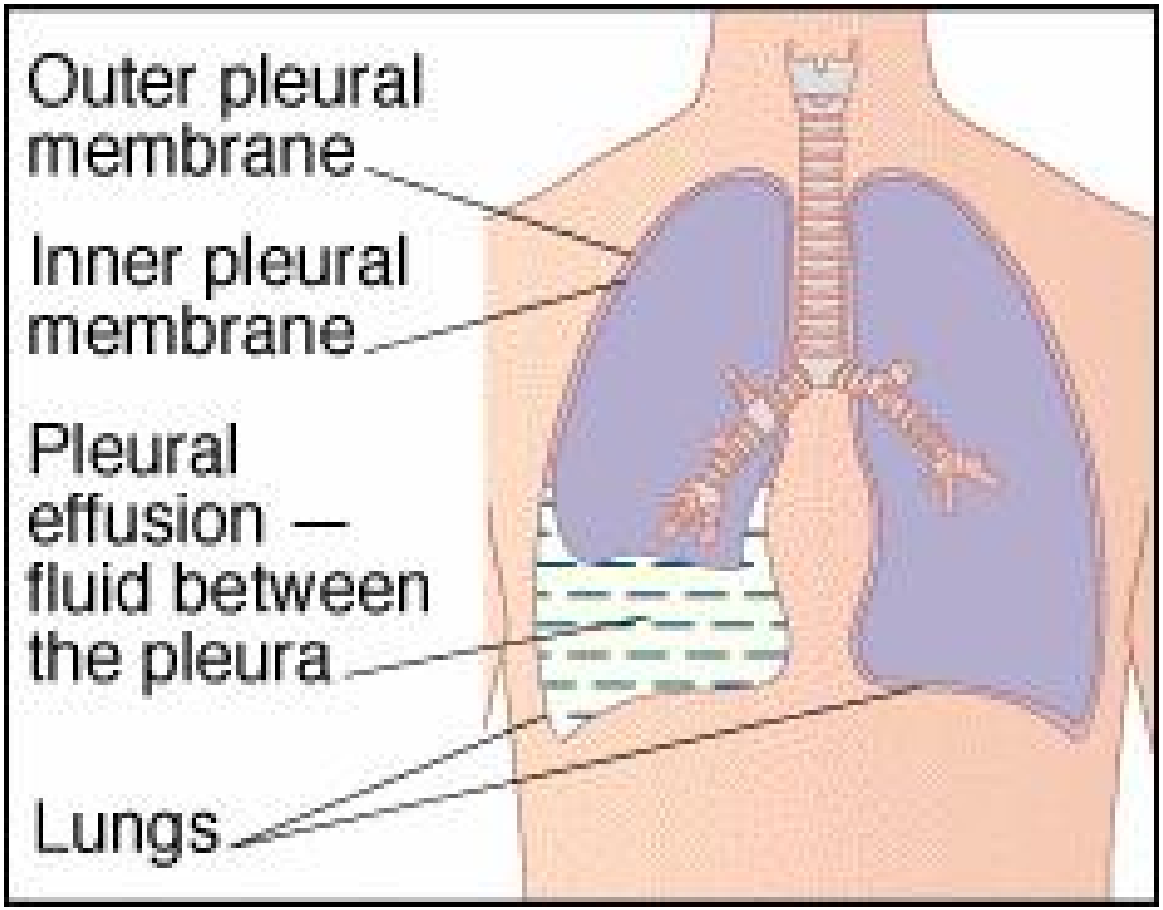

bronchiole
pulmonary artery
pulmonary vein
terminal bronchiole
alveolar pores
alveoli
capillary network
L. Shoemaker

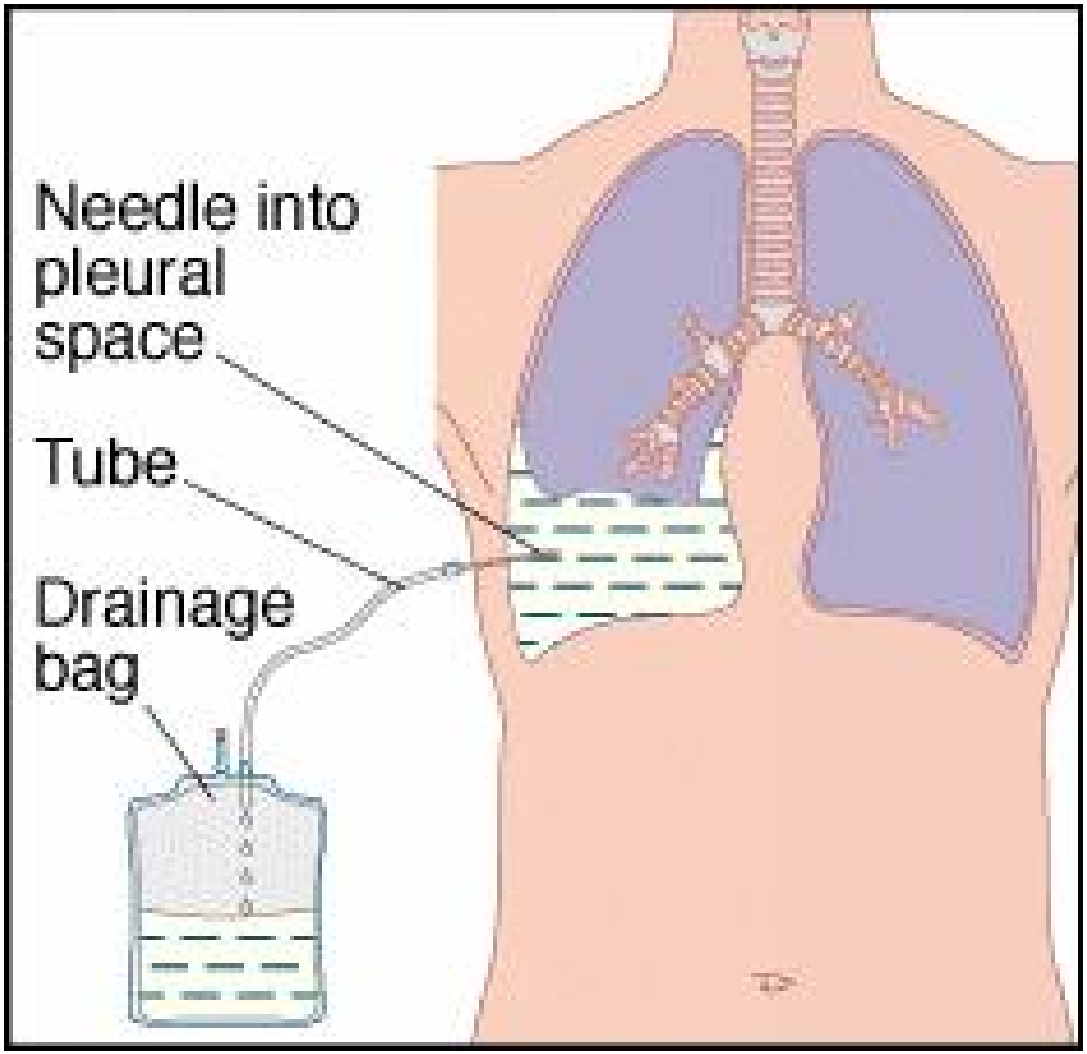



Normal Bronchiole
Asthmatic Bronchiole
J. Beck
M. Gerrity
open airway
muscle constriction
swollen mucous membrane
thick secretions

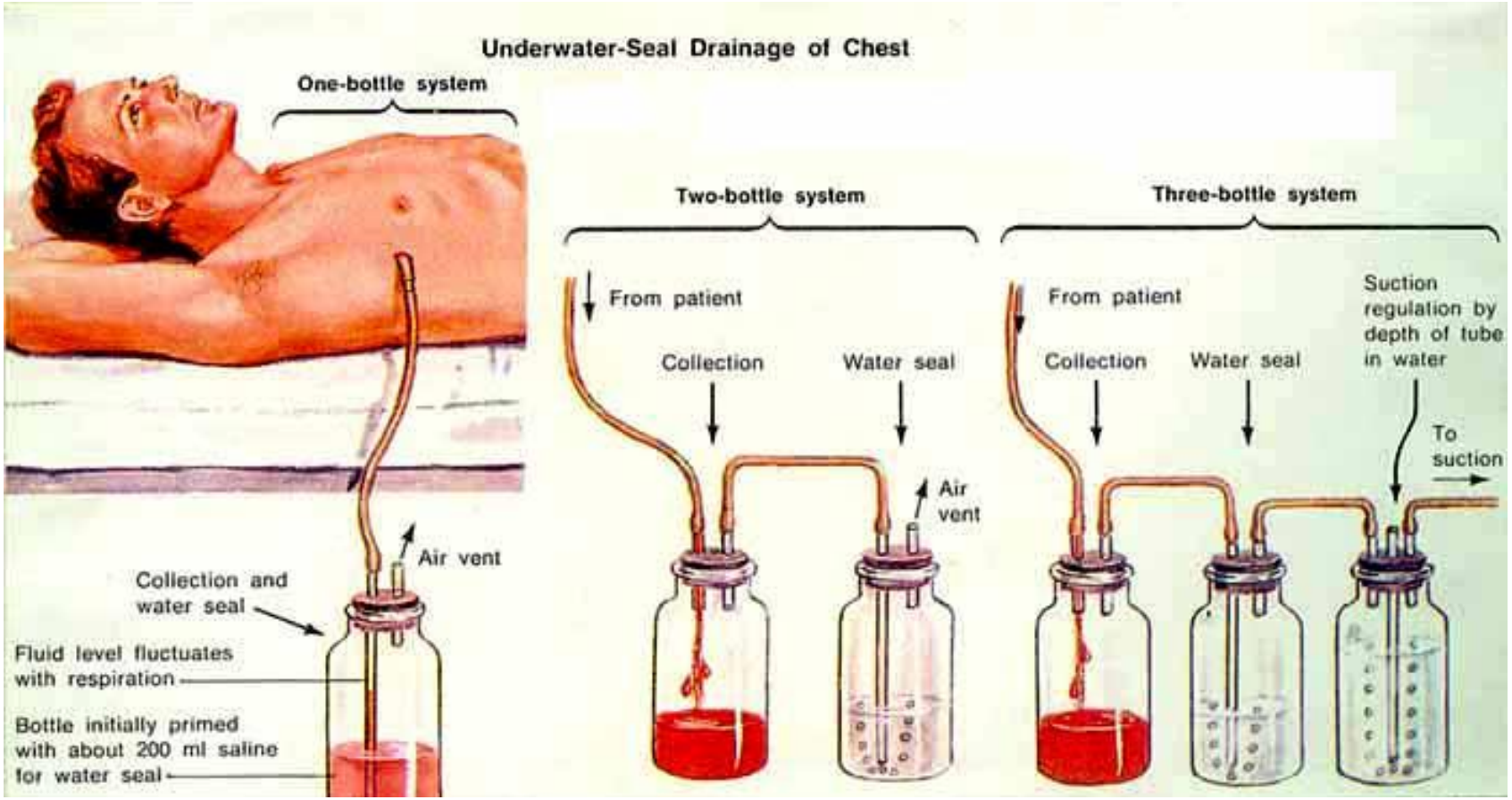

©UPHS


Sternum
Anterior mediastinum
Pericardial cavity
Thoracic wall
Lung
Heart (in middle mediastinum)
Parietal pericardium
Parietal pleura
Visceral pericardium
Visceral pleura
Pleural cavity
Esophagus
Bronchus
Posterior mediastinum
Thoracic vertebra

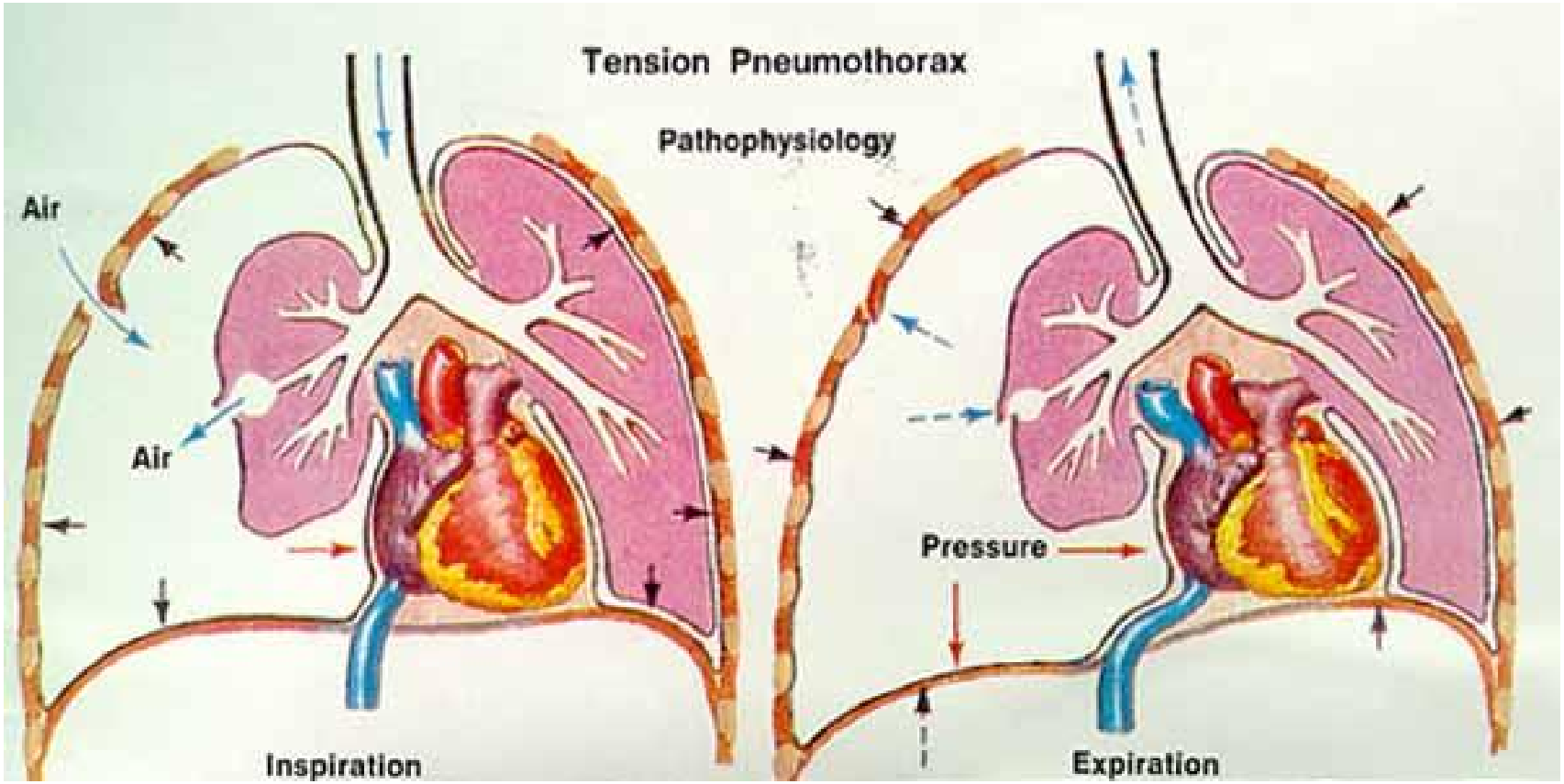

Outer pleural membrane
Inner pleural membrane
Pleural effusion — fluid between the pleura
Lungs

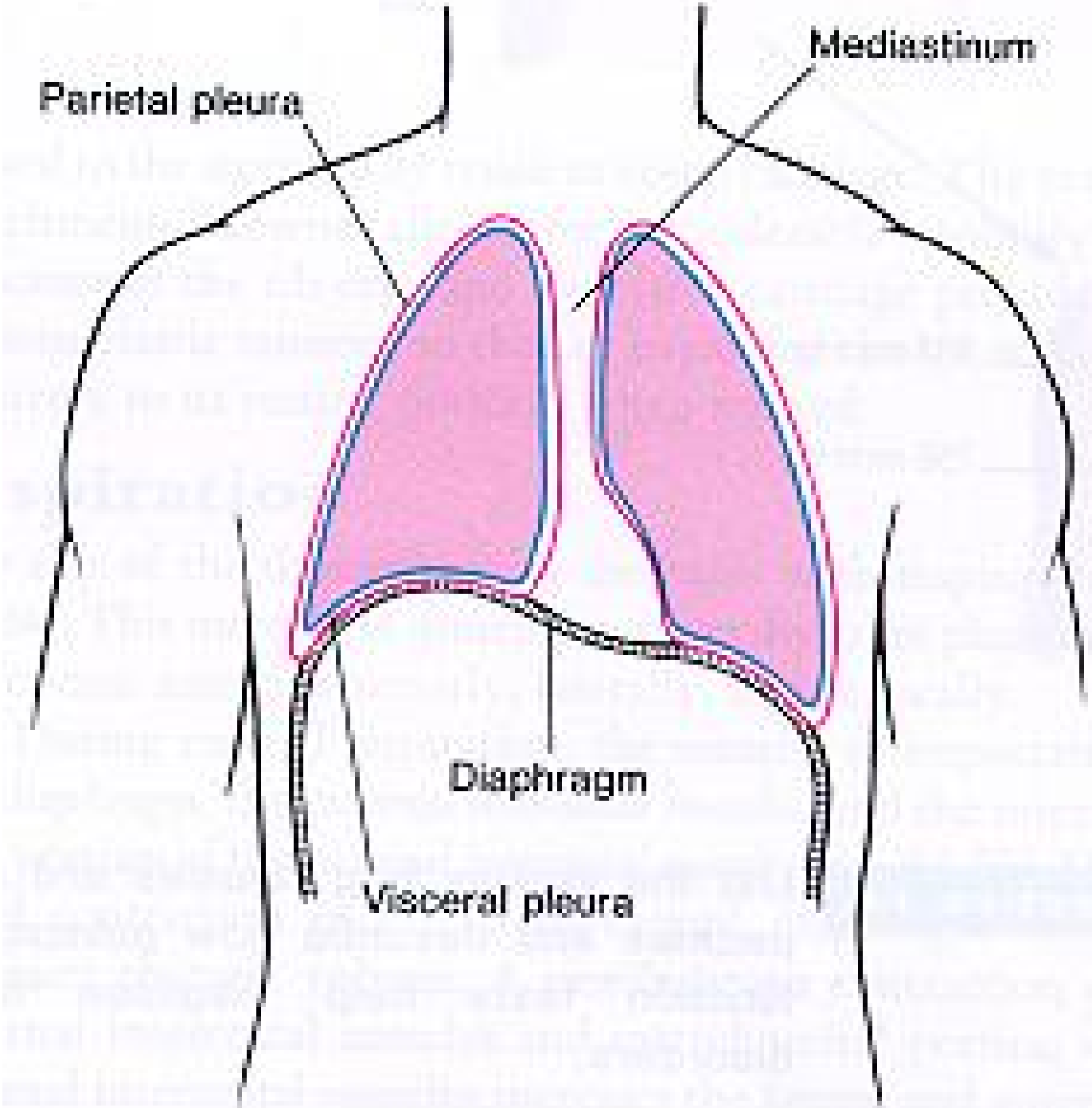

Needle into pleural space
Tube
Drainage bag

Hemothorax Chest Drainage

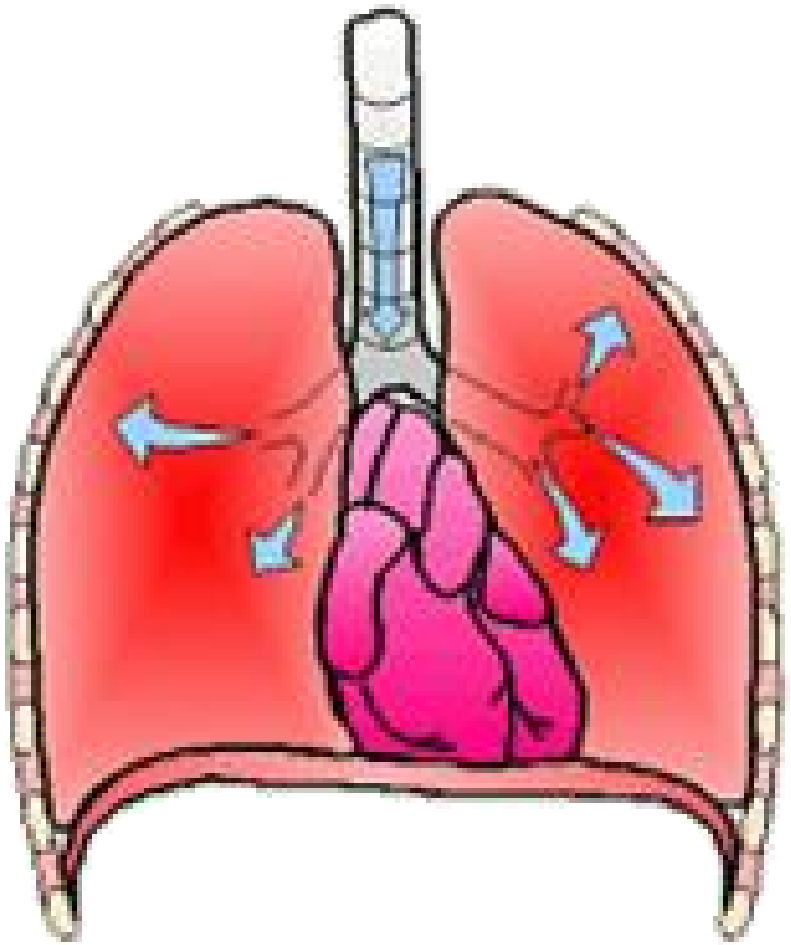


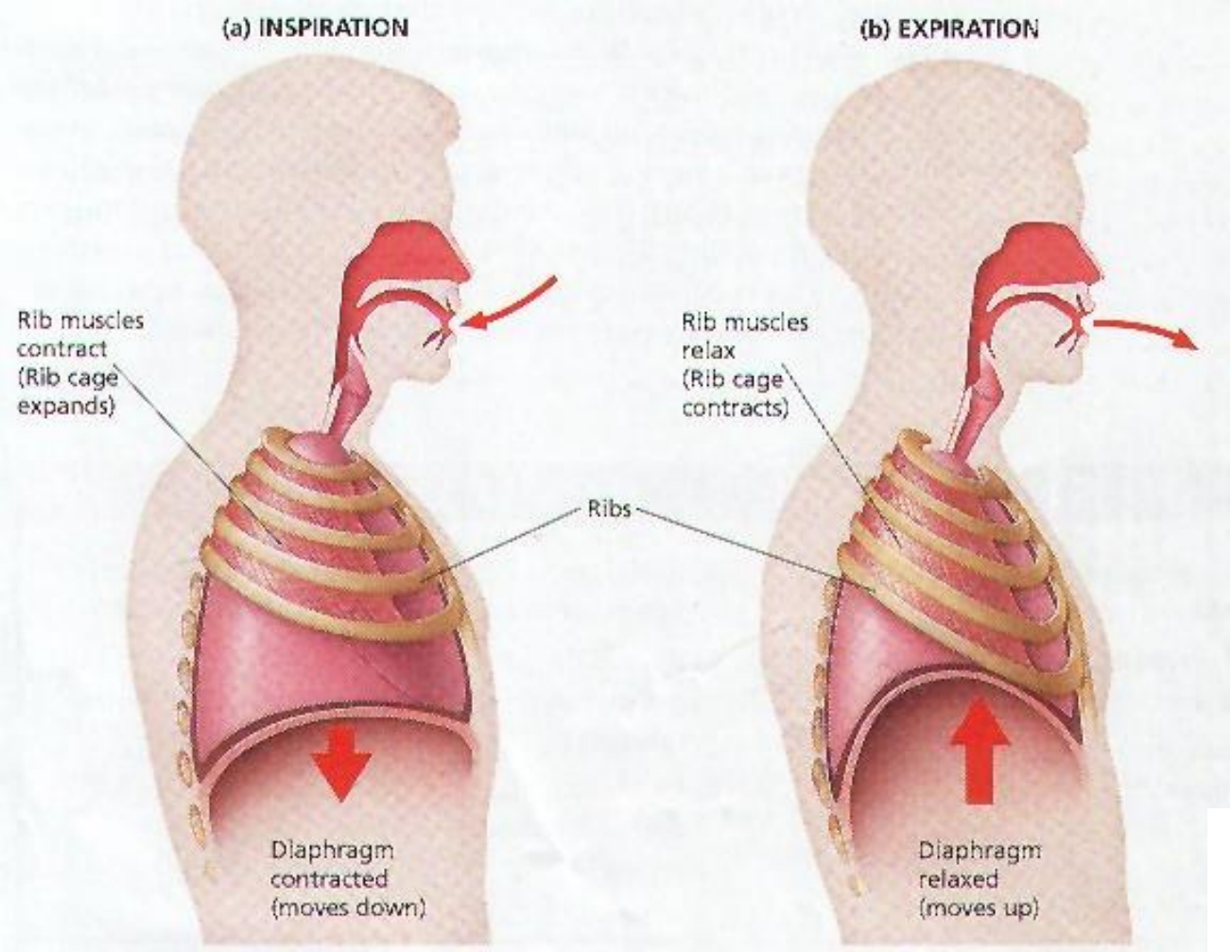
Pneumothorax

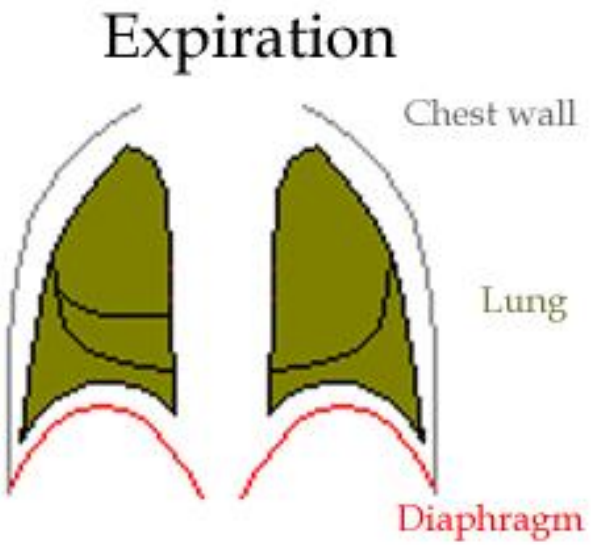



Mediastinum
Parietal pleura
Diaphragm
Visceral pleura

Dynamics of Breathing



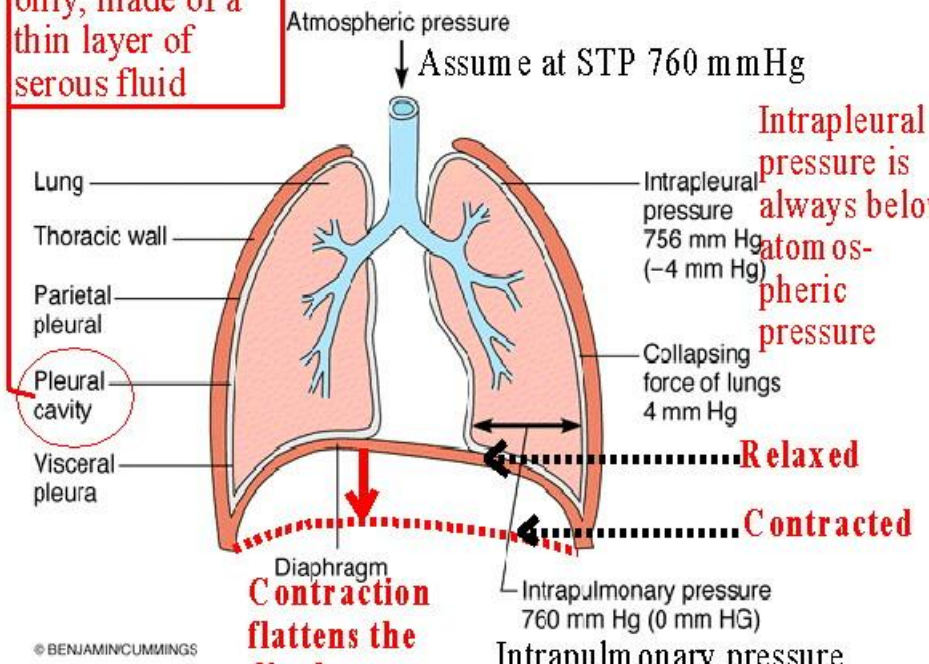

(a) INSPIRATION
(b) EXPIRATION
Rib muscles contract (Rib cage expands)
Rib muscles relax (Rib cage contracts)
Ribs
Diaphragm contracted (moves down)
Diaphragm relaxed (moves up)


Expiration
Chest wall
Lung
Diaphragm

Diaphragm

Functional Relationships of the Lungs and Associated Structures

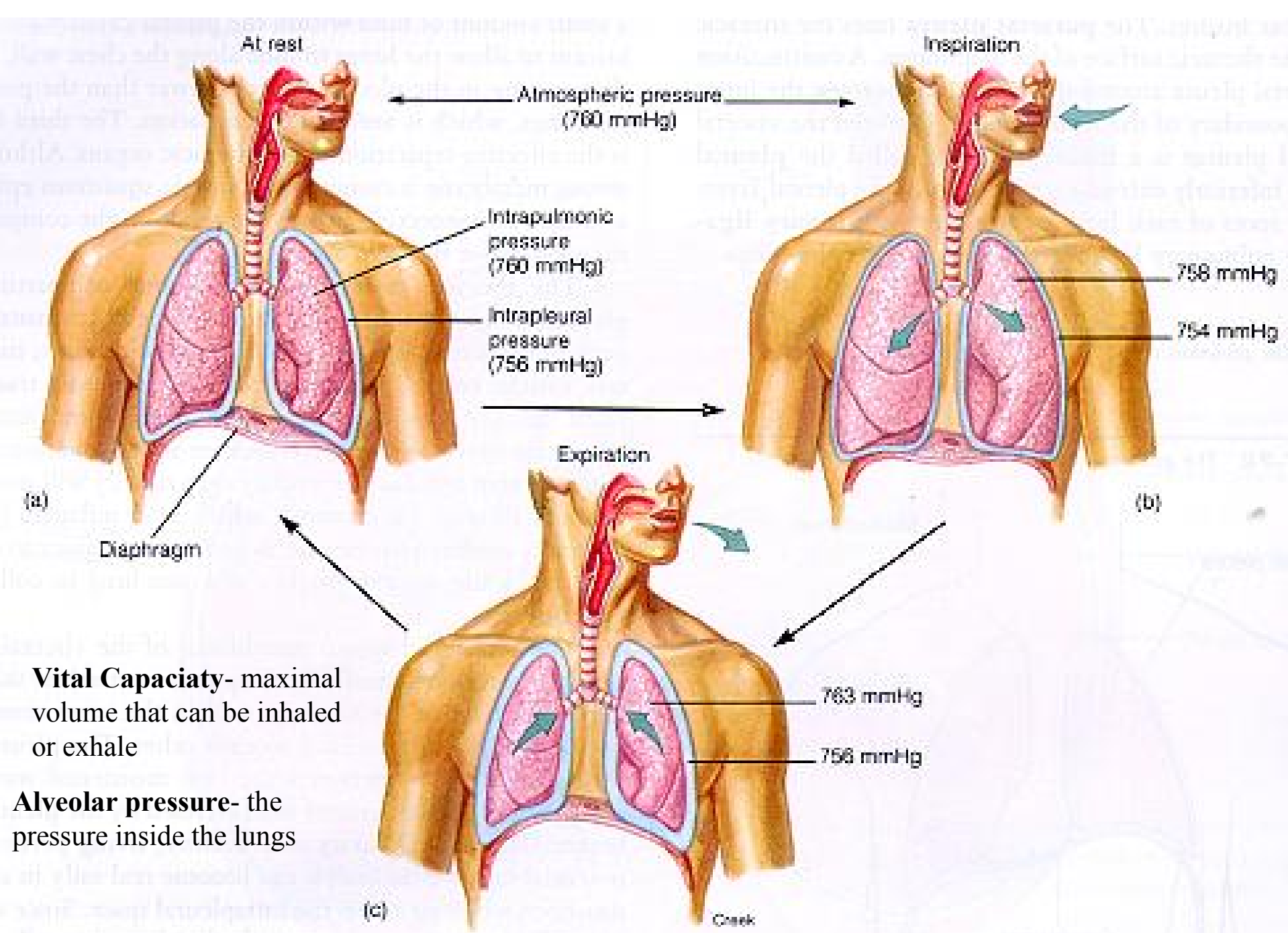
A potential space only, made of a thin layer of serous fluid



Intrapleural pressure is always below atmospheric pressure

Contraction flattens the diaphragm, pulling down on the thorax and lungs and increasing their volume

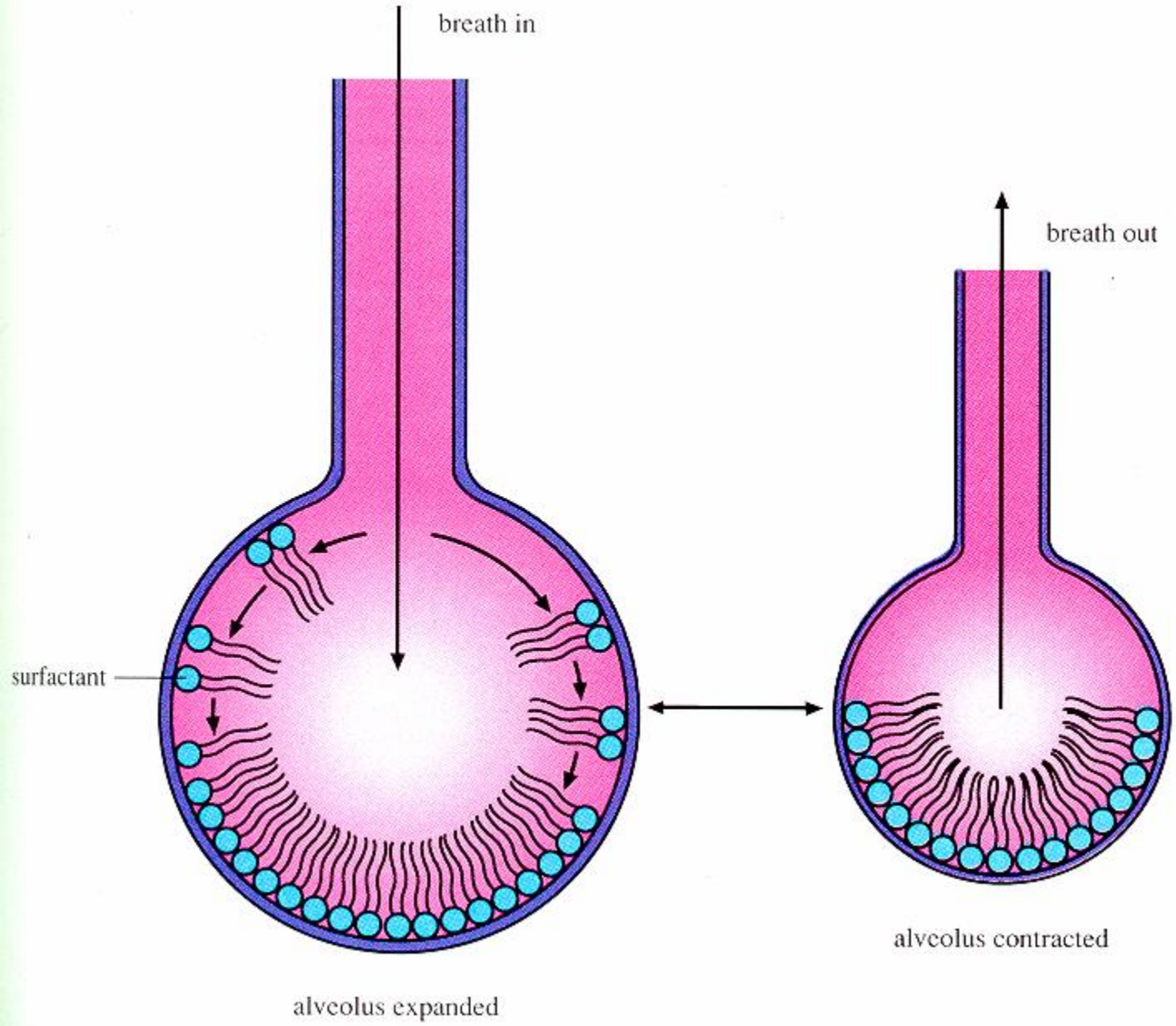
Intrapulmonary pressure averages the same as atmospheric pressure. See Figure 23.13



Vital Capaciaty- maximal volume that can be inhaled or exhale

Alveolar pressure- the pressure inside the lungs

Collapsed Lung



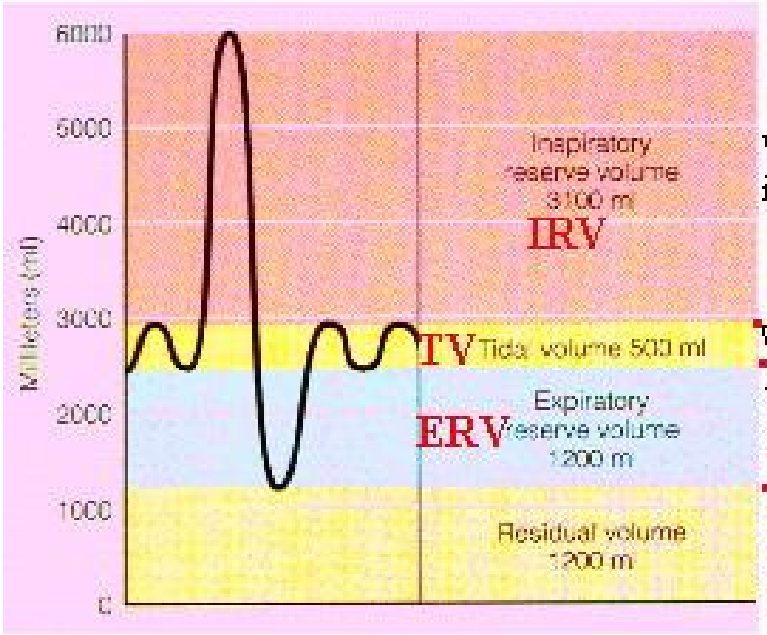
The pressure in the pleural cavity is subatmospheric inorder to keep the alveoli slightly inflated after the end of expiration.

This negative pressure overcomes the recoil force from the elastic bands around the alveoli.

A collapsed lung may be caused by air entering the pleural space from a surgical incision or a chest wound, airway obstruction, or lack of surfactant.

Surfactant- a phospholipid produced by the septal cells that prevents the alveolar walls from sticking together (surface tension)

Table of Lung Volumes



Volume which can be inspired beyond a restful inspiration.

Volume of a single breath, usually at rest.

Volume which can be expired beyond a restful expiration.

Volume remaining in the lungs after a maximum expiration. This volume keeps the alveoli inflated.

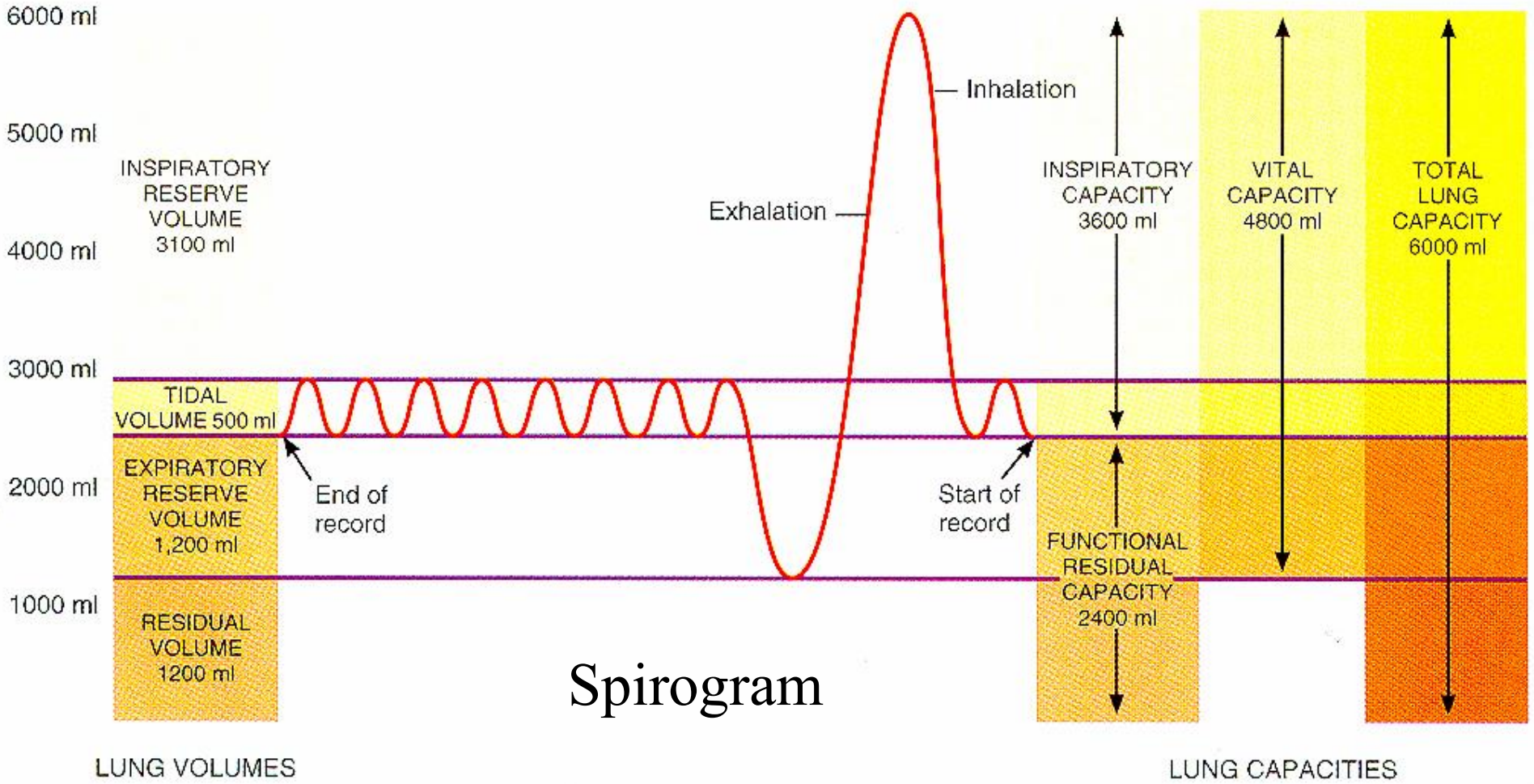
Vital Capacity VC

The vital capacity (VC) is the maximum volume which can be ventilated in a single breath. VC= IRV+TV+ERV. VC varies with gender, age, and body build Measuring VC gives a device for diagnosis of respiratory disorder, and a benchmark for judging the effectiveness of treatment. Vital Capacity is reduced in restrictive disorders, but not in disorders which are purely obstructive.

The FEV_1 is the % of the vital capacity which is expelled in the first second. It should be at least 75%. The FEV_1 is reduced in obstructive disorders.

Both VC and the FEV_1 are reduced in disorders which are both restrictive and obstructive.

Lung Capacities



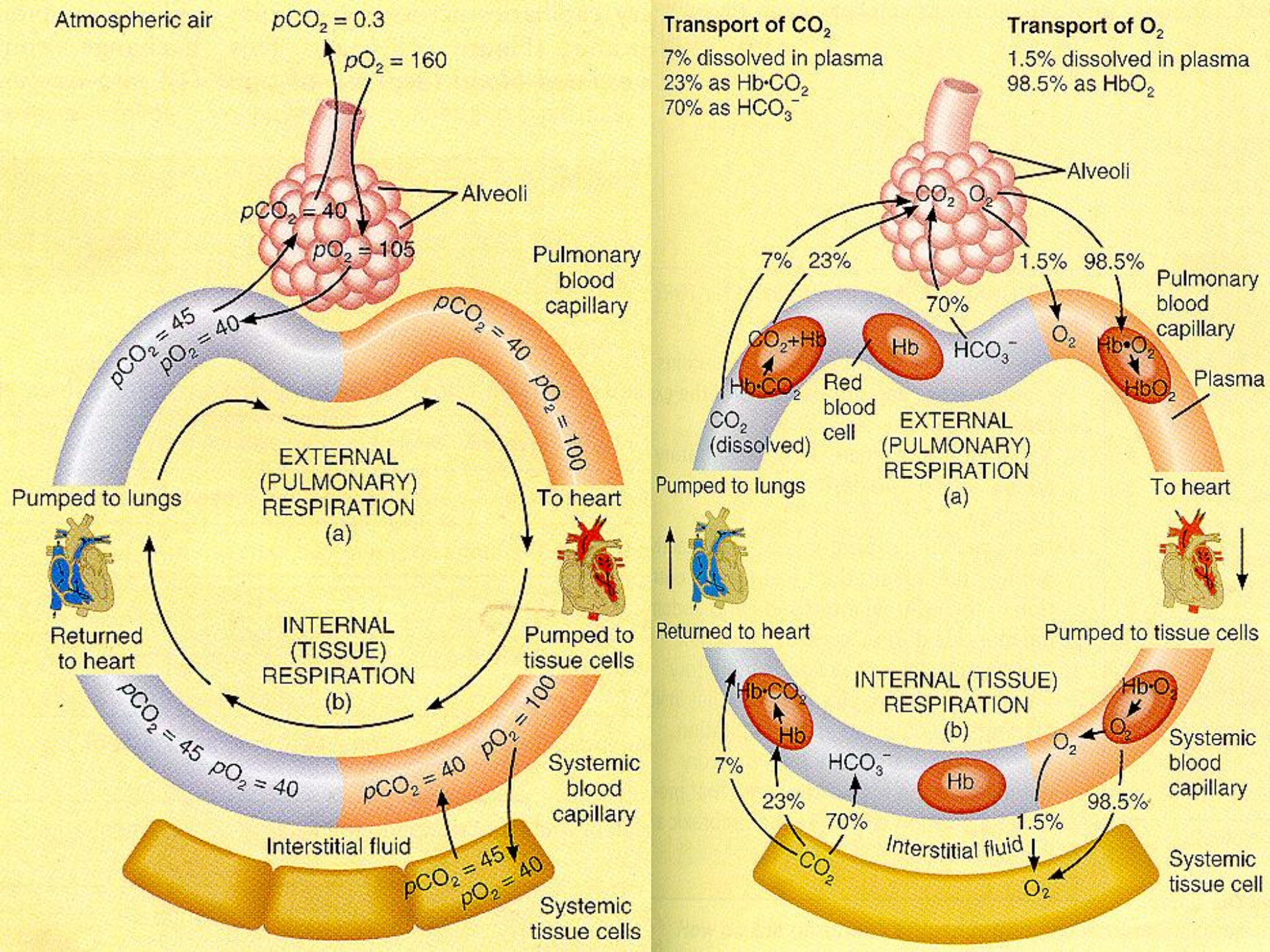
Spirogram

Anatomic dead space- aprox 30% of inhaled air

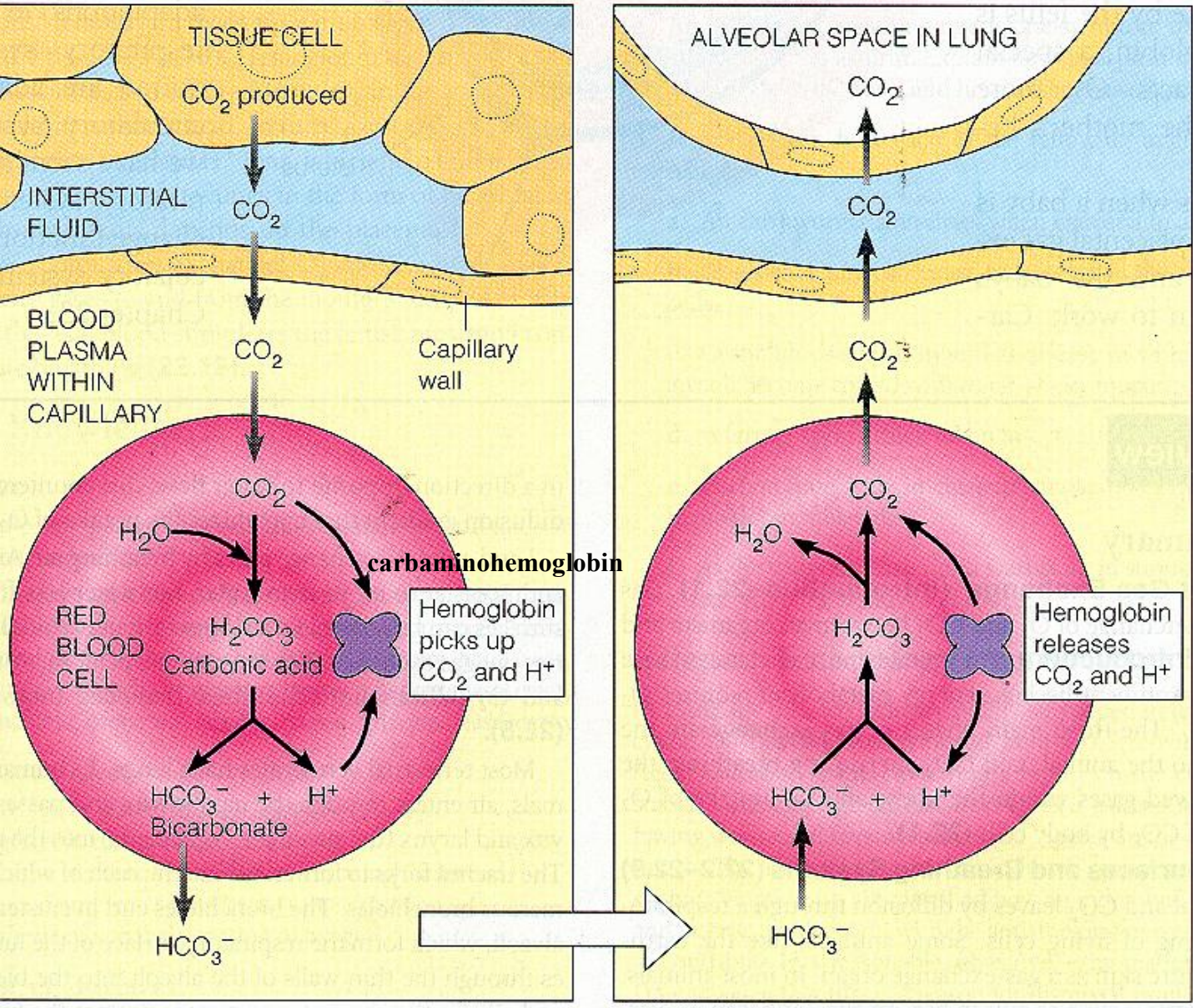
Minute volume of respiration- total air taken in during 1 min.

The efficiency of external respiration depends on several factors

- altitude
  - high altitude sickness (shortness of breath, nausea, dizziness)
- surface area available for O2-CO2 exchange
- minute volume respiration
  - drugs, such as morphine, slow down the respiratory rate
- the amount of O2 that reaches the alveoli (plugged passages)


Atmospheric air
$pCO_2 = 0.3$
$pO_2 = 160$
Alveoli
$pCO_2 = 40$
$pO_2 = 105$
Pulmonary blood capillary
$pCO_2 = 45$
$pO_2 = 40$
$pCO_2 = 40$
$pO_2 = 100$
Pumped to lungs
To heart
EXTERNAL (PULMONARY) RESPIRATION (a)
Returned to heart
Pumped to tissue cells
INTERNAL (TISSUE) RESPIRATION (b)
$pCO_2 = 45$ $pO_2 = 40$
$pCO_2 = 40$ $pO_2 = 100$
Systemic blood capillary
Interstitial fluid
$pCO_2 = 45$
$pO_2 = 40$
Systemic tissue cells
Transport of CO_2
7% dissolved in plasma
23% as $Hb{\cdot}CO_2$
70% as HCO_3^-
Transport of O_2
1.5% dissolved in plasma
98.5% as HbO_2
Alveoli
CO_2 O_2
7% 23%
70%
1.5% 98.5%
Pulmonary blood capillary
CO_2+Hb
Hb
HCO_3^-
O_2
$Hb{\cdot}O_2$
$Hb{\cdot}CO_2$
HbO_2
Plasma
Red blood cell
CO_2 (dissolved)
EXTERNAL (PULMONARY) RESPIRATION (a)
Pumped to lungs
To heart
Returned to heart
Pumped to tissue cells
INTERNAL (TISSUE) RESPIRATION (b)
$Hb{\cdot}CO_2$
Hb
$Hb{\cdot}O_2$
O_2
7%
HCO_3^-
Hb
23%
70%
98.5%
1.5%
Systemic blood capillary
CO_2
Interstitial fluid
O_2
Systemic tissue cell

$$CO_2 + H_2CO_3 \rightleftharpoons HCO3^- + H^+$$



A. CO_2 transport in the body tissues

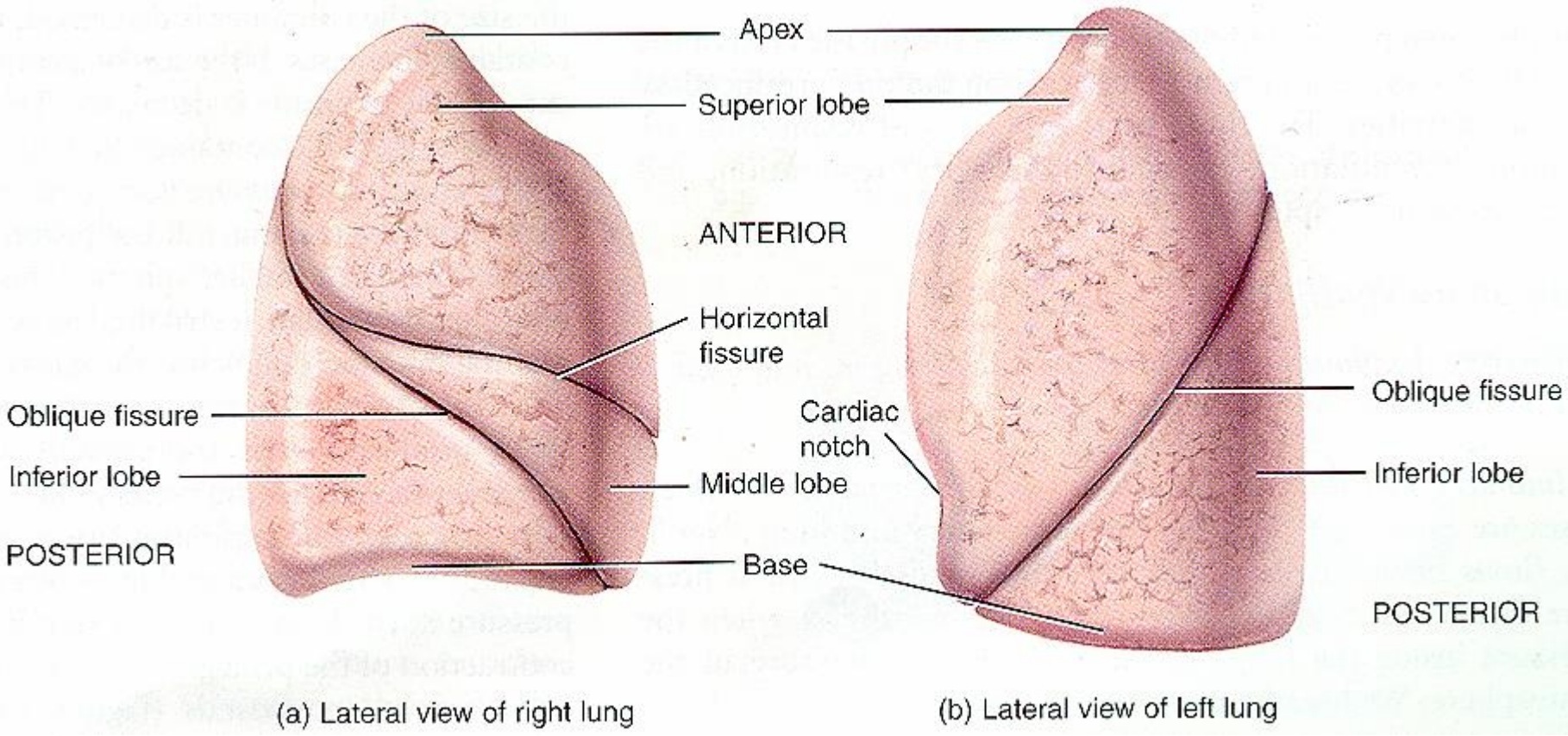
B. CO_2 transport in the lungs

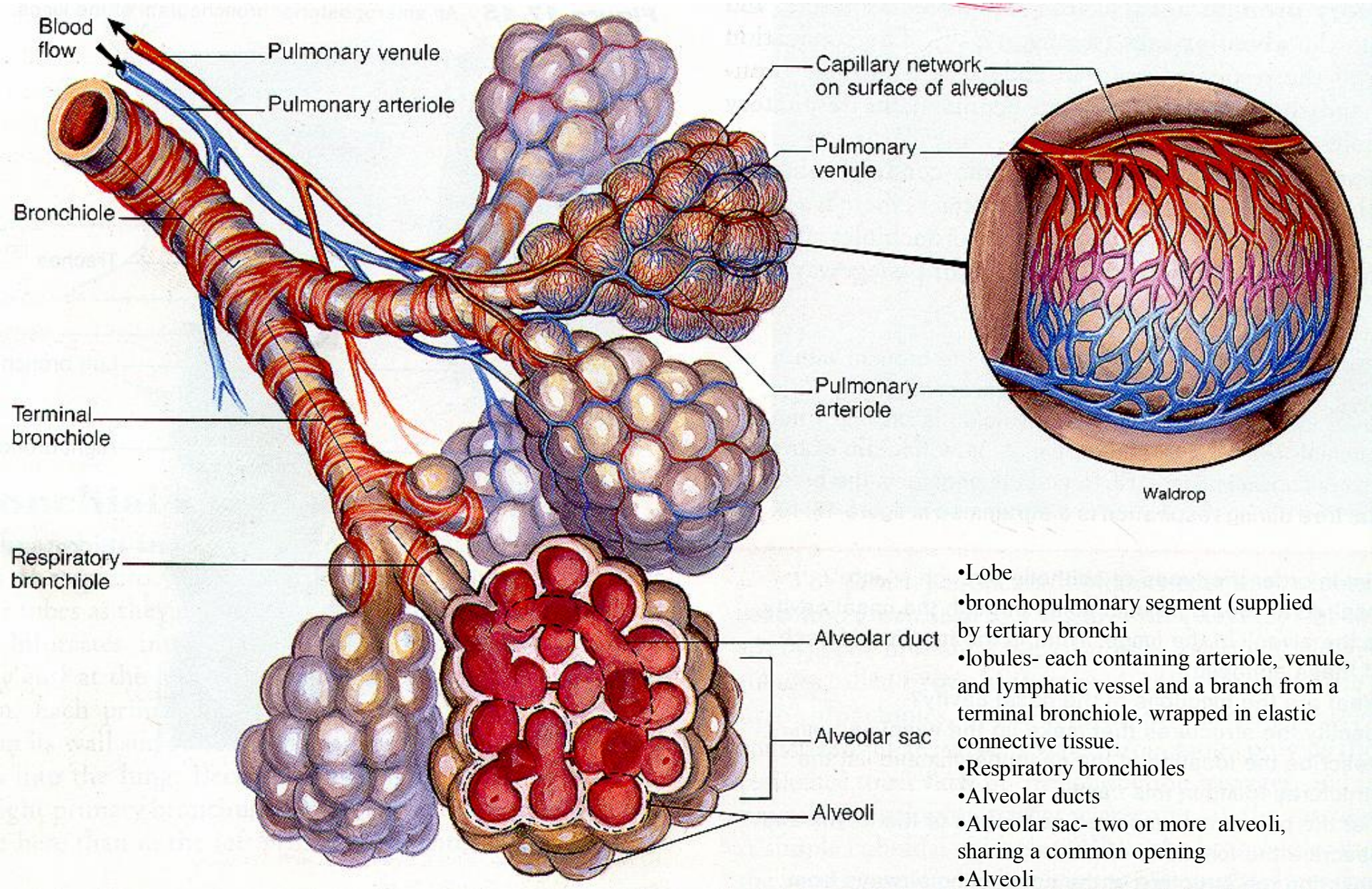
The release of O2 from hemoglobin depends on

- difference in pO2 between blood and tissue
- pH- increase release
- temperature- increase release

- Carbon monoxide poisoning- CO has a stronger affinity for hemoglobin than oxygen.

- Hypoxia- dificiency of O2 at the tissues.
  - Low pO2 in arterial blood
  - high altitude
  - too little functioning hemoglobin (anemia)
  - inefficient blood transport as in heart failure
  - inability of tissue to use O2 properly as in cyanide poisoning

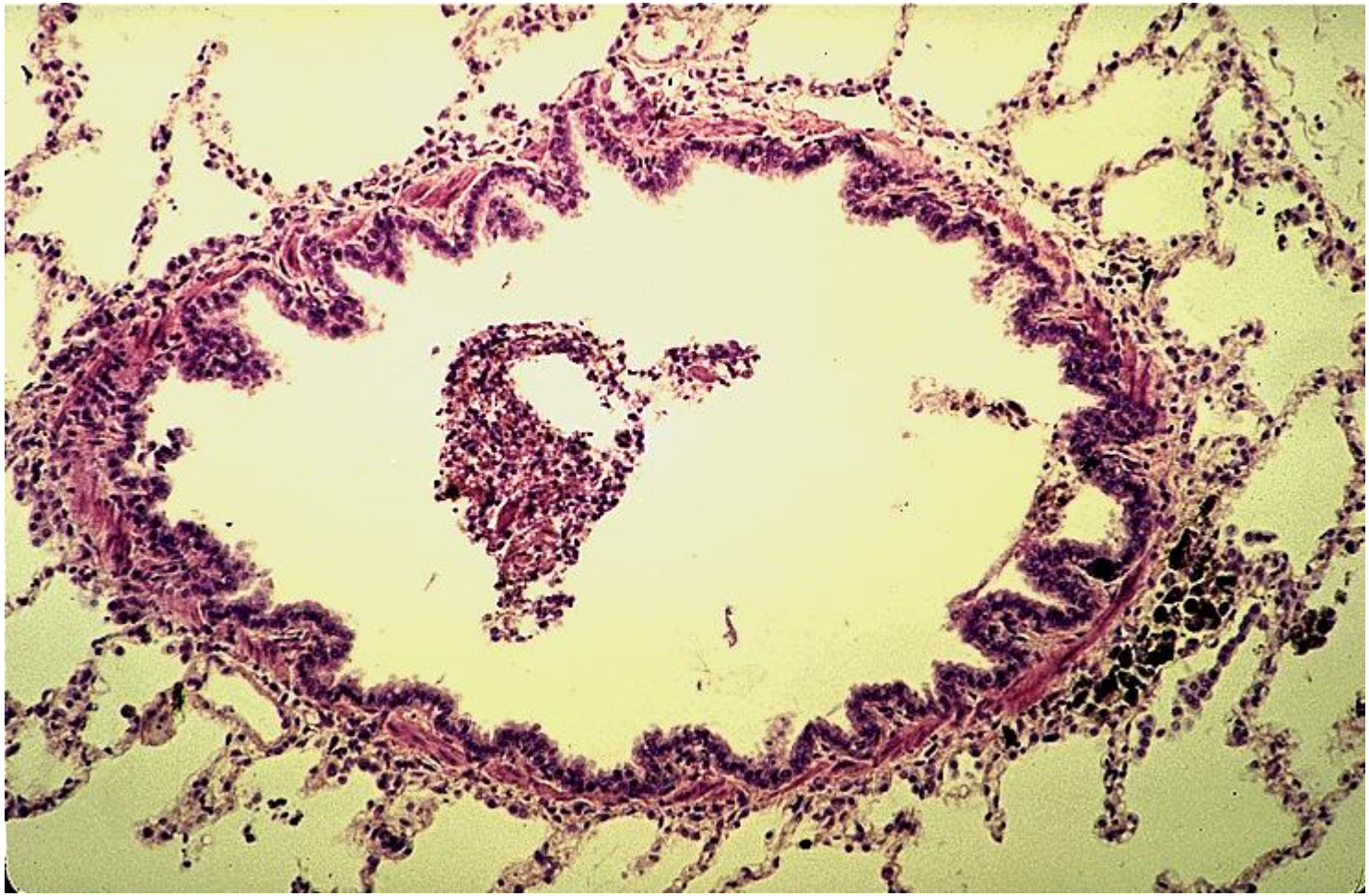

Apex
Superior lobe
ANTERIOR
Horizontal fissure
Oblique fissure
Inferior lobe
Middle lobe
POSTERIOR
Base
(a) Lateral view of right lung
Cardiac notch
Oblique fissure
Inferior lobe
POSTERIOR
(b) Lateral view of left lung



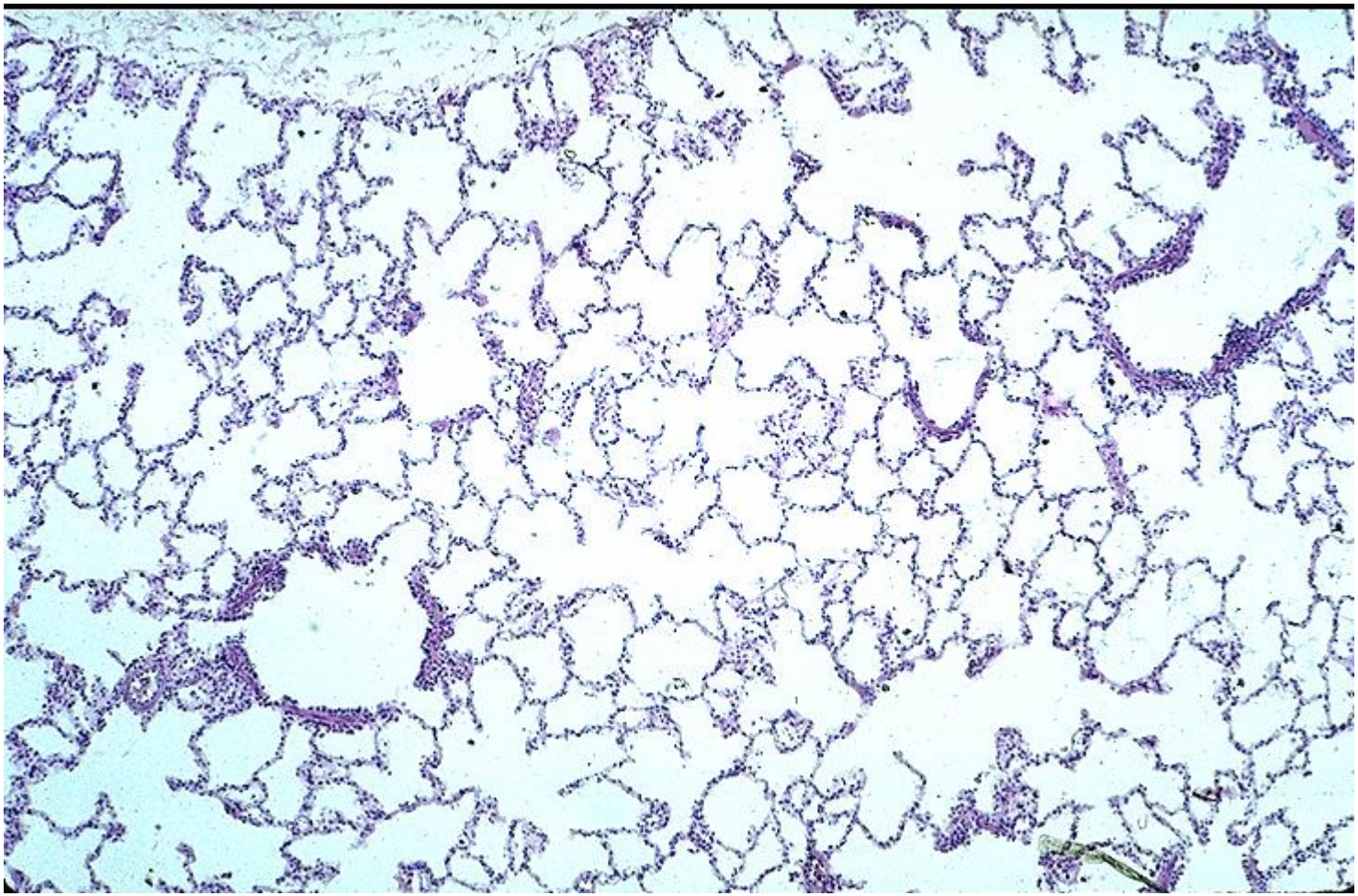
- Lobe
- bronchopulmonary segment (supplied by tertiary bronchi
- lobules- each containing arteriole, venule, and lymphatic vessel and a branch from a terminal bronchiole, wrapped in elastic connective tissue.
- Respiratory bronchioles
- Alveolar ducts
- Alveolar sac- two or more alveoli, sharing a common opening
- Alveoli

Bronchus

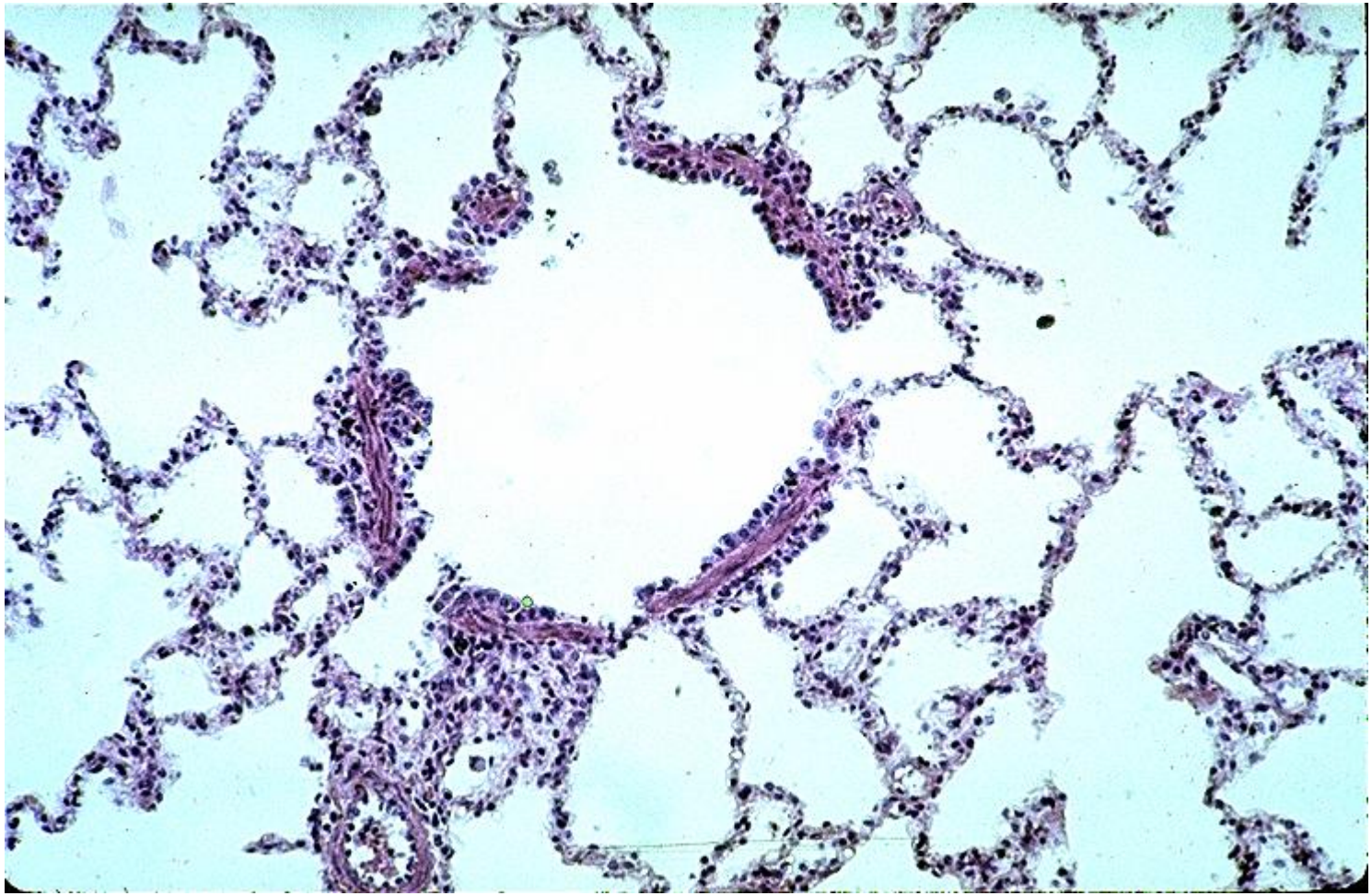
Bronchiole



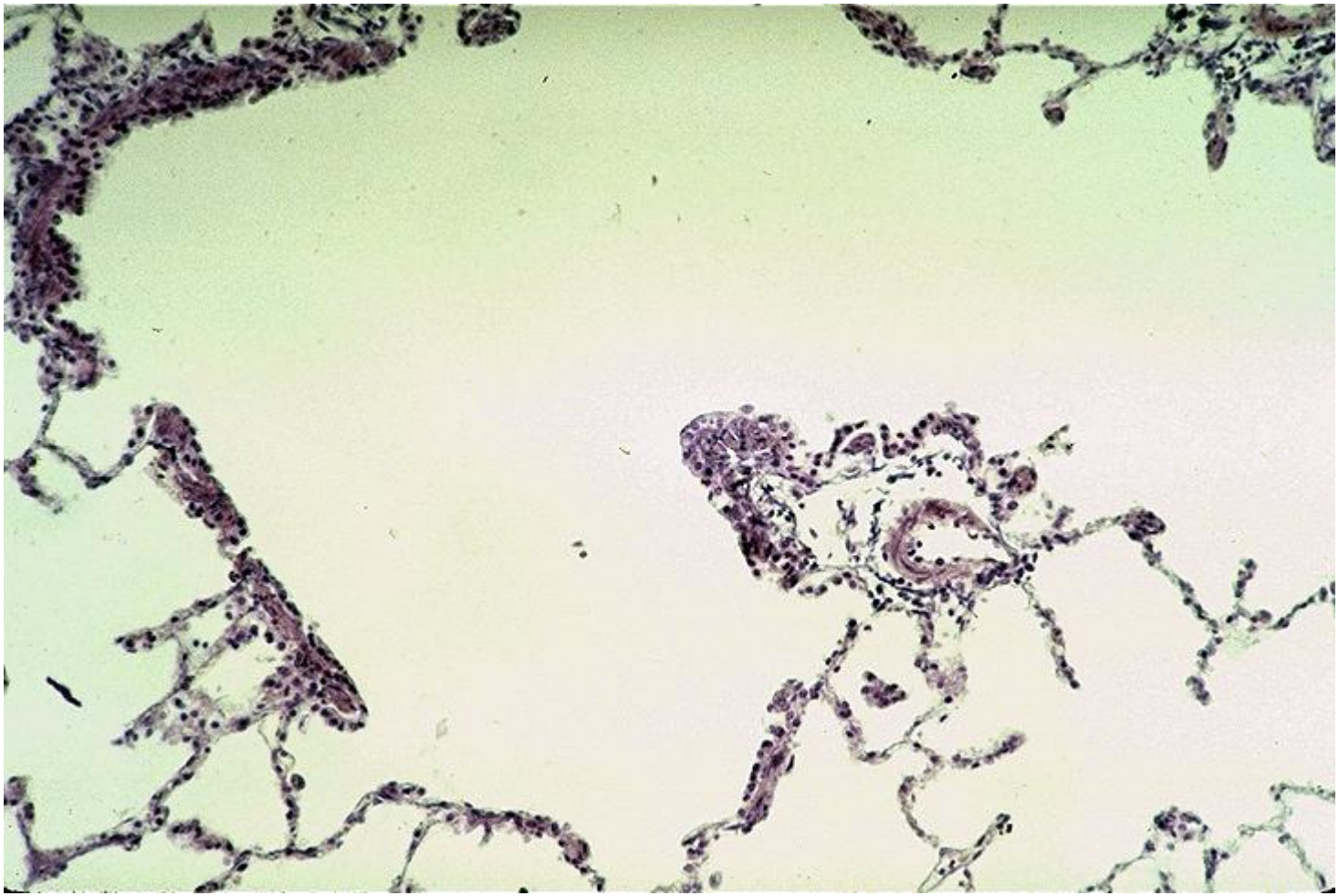
Respiratory Bronchiole



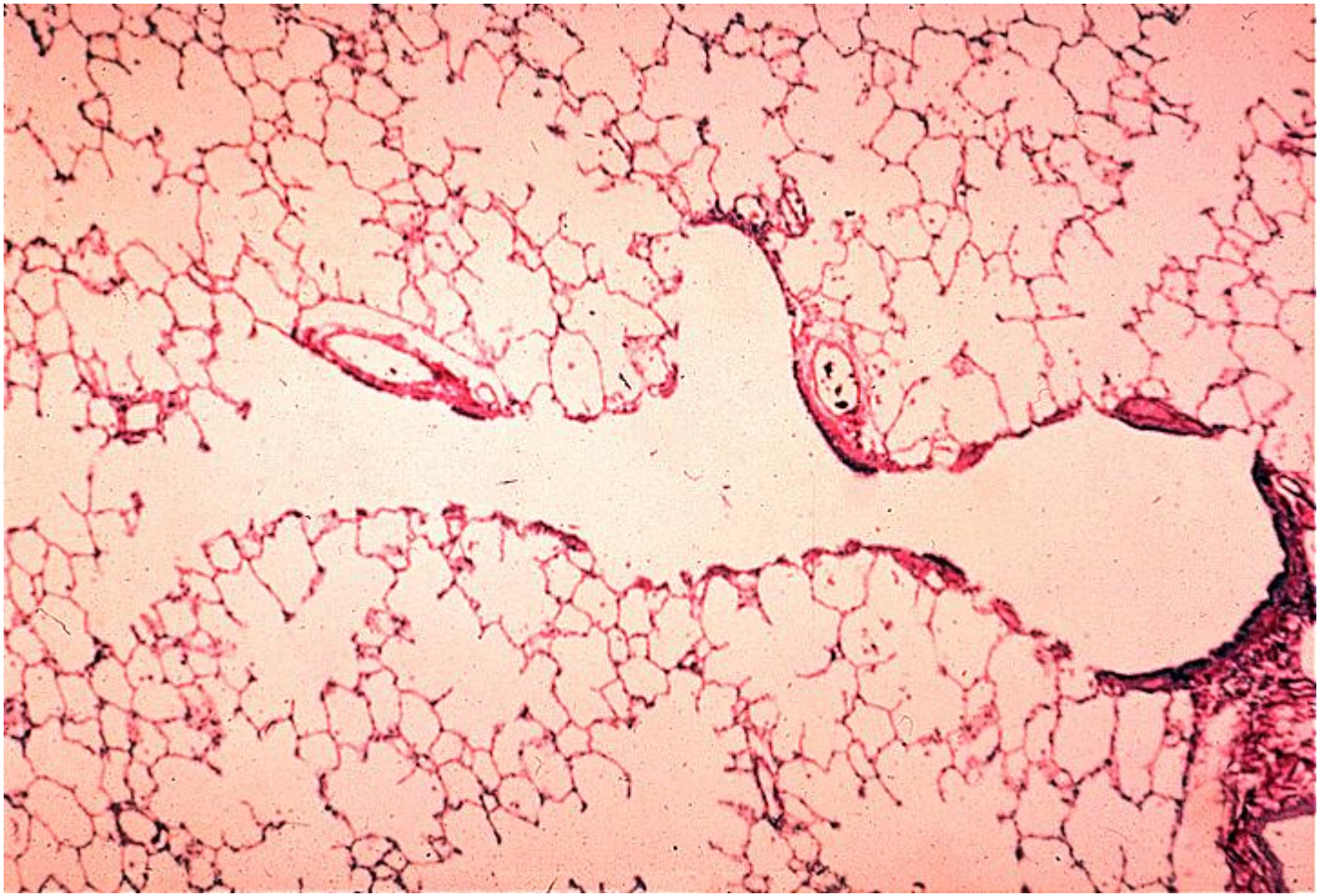
Respiratory Bronchiole



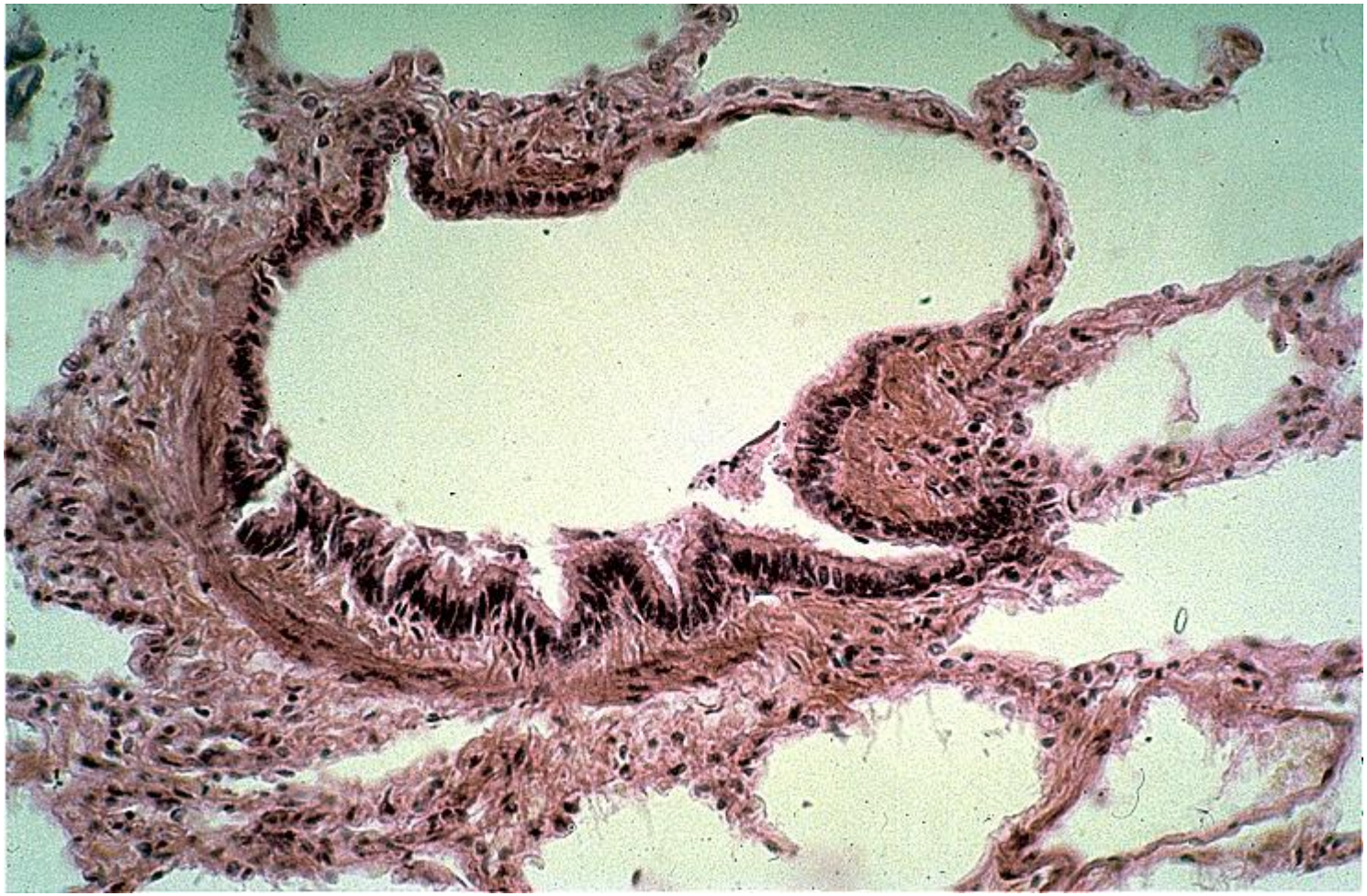
Respiratory Bronchiole

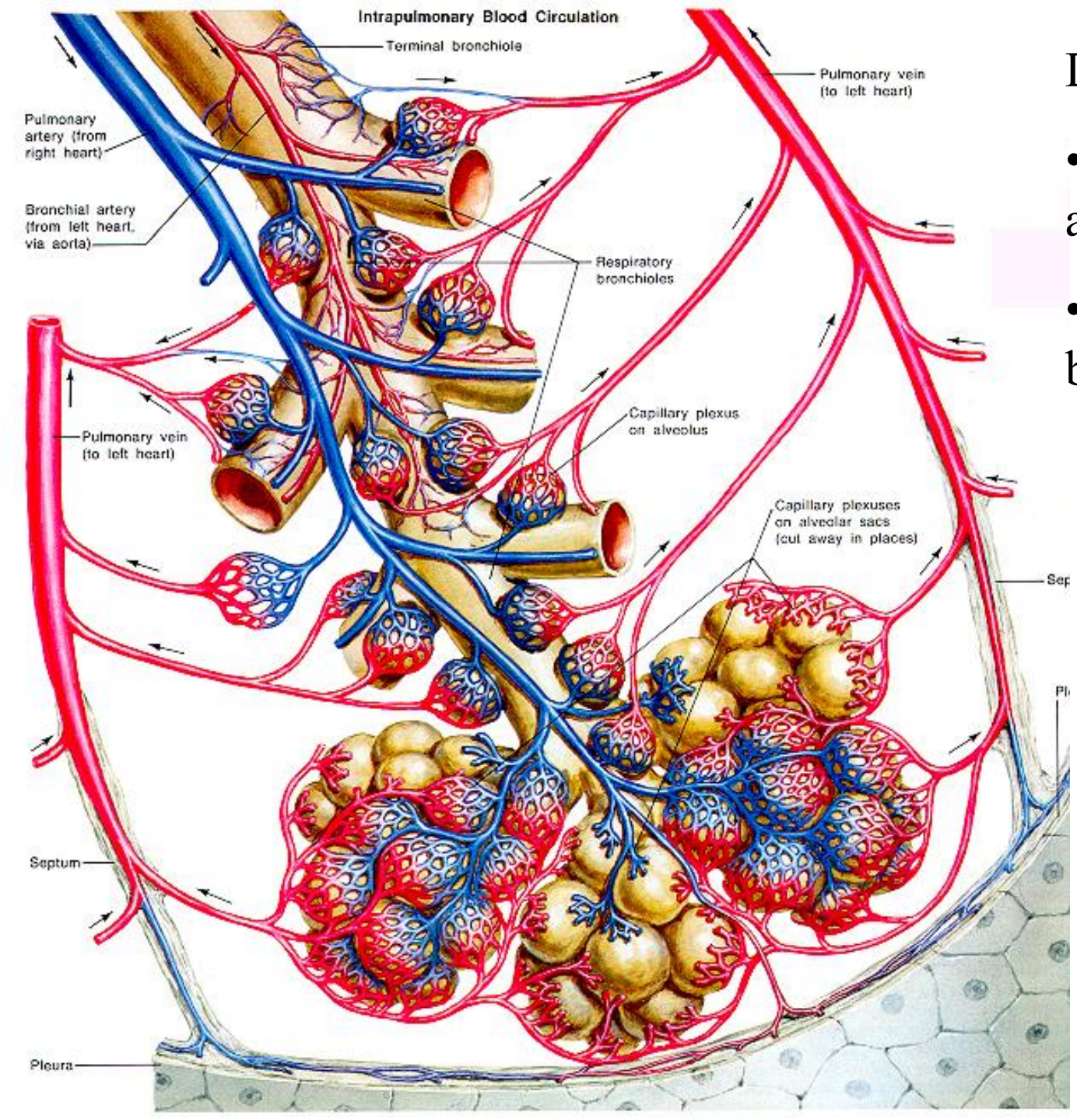


Respiratory Bronchiole Alveolar Duct



Respiratory Bronchiole Alveolus




Intrapulmonary Blood Circulation
Terminal bronchiole
Pulmonary vein (to left heart)
Pulmonary artery (from right heart)
Bronchial artery (from left heart, via aorta)
Respiratory bronchioles
Capillary plexus on alveolus
Pulmonary vein (to left heart)
Capillary plexuses on alveolar sacs (cut away in places)
Septum
Pleura

Double Blood Supply

- From Pulmonary arteries
- From the aorta via bronchial arteries